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Changing Logistics Career Path: A New Era

Lieutenant General John M. Nowak, USAF

The Present

Times are changing! What an understatement! Perhaps, never in the history of the Air Force have we experienced such radical changes as we have in the last few years. These profound changes have created challenges for our Air Force logistics officers that are more complex than ever. Our logistics officers now require a broad base of technical expertise, job knowledge, and work experience. MAJCOM reorganization, objective wing compliance, personnel reductions, and constrained budgets have caused every organization in the Air Force to re-look at the way they do business. Changing mission requirements suggest we now take a new approach to restructuring professional logistics officer development.

Downsizing of the Air Force, combined with the ever-increasing interaction among logistics disciplines, creates a need to consolidate current logistics AFSCs into a single multifunctional logistics career path. The goal is to develop a qualified field grade officer to fill multidisciplined logistics jobs across the logistics spectrum and at all grades. This new career path will allow for, and in fact, demand early specialization. Cross flowing between disciplines, and across operational environments, will become the norm in career development. Future Air Force logistics officers must have a wide breadth of experience in order to fill senior officer positions.

In the past, the Air Force developed several kinds of logistics officers who specialized within a specific discipline. For example, a maintenance officer was expected to stay within maintenance, accepting career opportunities at wing, MAJCOM, and Air Force level or perhaps the wholesale arena. In addition, the maintenance officer gained experience in several different weapon systems. The result was a seasoned maintenance officer who could fill senior positions such as Deputy Commander for Maintenance at any wing in the Air Force. As you know, the senior logistics positions at the wing have changed significantly (objective wing). Therefore, we need a new logistics career path, which meets the needs of the individual and the Air Force.

Challenges facing our logistics officers today are extremely complex and require an understanding of the interrelationships of all logistics disciplines. Modern logistics blurs the lines between wholesale, retail, and joint communities. Therefore, we must learn to manage logistics as a complete process that encompasses the whole picture—transportation, supply, maintenance, and plans to include wholesale, retail, and joint.

To illustrate, let's examine the current responsibilities of the Logistics Group Commander (LG/CC). He/she possesses massive executive management responsibilities across a number of disciplines: maintenance, supply, transportation, contracting, and logistics planning. Our current career paths do not prepare nor develop replacements for key positions that are multidisciplined and multifaceted. If we are going to manage logistics in this way, there is a need for broader education and experience in the total logistics process. Therefore, logistics officer professional development requires adjustment to meet these changing needs.

In early March, we established a Logistics Officer Career Development Working Group. The purpose was to inventory and review the forces of change in today's logistics working environment, determine mission needs, and develop a career development plan to meet those needs. In April, the Logistics Board of Advisors (BOA) received a briefing on the working group's initiatives. The BOA approved the recommended initiatives and the direction of their efforts.

The Future

Let's examine the future direction of our logistics community. The premise is to start developing holistic logistics officers from initial accession. New officers will gain experience in a minimum of two disciplines, and, once they reach field grade rank, they will be eligible for a "LOGISTICIAN" AFSC. Company grade officers must establish breadth and depth in their initial discipline. Logistics Group Commanders or senior logistics officers must move company grade officers from job to job to develop that experience within their discipline. Upon establishing a base of expertise, young officers should move to another specialty to increase their logistics experience. This career enhancement will prepare the junior officer for field grade and senior officer positions.

New training requirements are being developed to support the logistics career path. The training concept complies with the "Year of Training" initiatives. Career Field Education and Training Plans (CFETP) are currently being developed for specific disciplines. Courses will contain a short core block of instruction on all logistics disciplines. The idea is to start from the beginning to develop logistics officers who are aware of the big logistics picture. Also, bridge courses are being developed to expedite and ease an officer's movement from one logistics specialty to another. Field grade officers will attend a Logistics Officers' Course, which will cover all logistics disciplines.

As you can see, many of these initiatives are still in the development state, and much work remains to iron out all the details. Functional managers are busy drafting CFETPs laying the foundation for the overall logistics career path. We need your input. Become involved. Contact your functional manager at your MAJCOM. Our primary goal is to create a career path that provides well-prepared logistics officers to meet Air Force and joint mission requirements. To do that, we need to develop individual officers, educated, trained, and experienced in all facets of logistics.

Lieutenant General Nowak is the Deputy Chief of Staff for Logistics, HQ USAF.

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A Case for Eliminating the Initial Provisioning of Spares

Charles F. Youther

Introduction

This paper is unashamedly intended to advocate a position. It is my sole purpose to put forward a proposal to change the basic philosophy used to initially support new major weapon systems entering the Department of Defense (DOD) inventory. This proposal is not my exclusive and original creation; rather, it is merely a formal compilation of ideas based on the insight and labor of many skilled and dedicated individuals who have been diligently striving to improve the DOD provisioning process over the last several years. I claim no credit for the wisdom that went into recognizing the need for the changes recommended below; my role is limited to serving as a spokesperson for the combined work of many others. Any errors of fact or logic, however, are mine alone.

This short paper will initially address the current state of the provisioning process in the DOD as a reflection of the basic philosophy used for system acquisition during the Cold War era. It will then attempt to identify basic deficiencies in that process, many of which are accentuated by the current shift in acquisition philosophy since the perceived end to the Cold War. It will then put forward a recommendation as to how that process could be fundamentally changed to correct those deficiencies.

The Provisioning Process

Over the last four or five years, there truly appears to have been a cultural change among those responsible for basic acquisition policy. Where as late as the 1987 version of the DOD's basic acquisition policy directive, DODD 5000.1, *Major and Non-Major Defense Acquisition Programs*, emphasized that "[a] primary goal in developing an acquisition strategy is to minimize the time it takes to satisfy the identified need," (3:5) the current version states:

> Acquisition strategies and program plans shall be tailored to accomplish established program objectives and to control risk. . . . *Schedule shall be subject to trade-offs as a means of keeping risk at acceptable levels.* (4:1-5) (Emphasis added.)

The philosophical change here is clear: During the Cold War, when the perceived existential risk was high, policy makers were willing to accept high levels of intra-program risk and the enormous resource investments and potential waste such management decisions could entail in order to increase the probability of fielding fully capable weapon systems as rapidly as possible. Now that the perceived level of existential risk is much lower, policy makers clearly are much less willing to accept high levels of risk within acquisition programs and are much more willing to delay the fielding of robustly supported systems in order to optimize or minimize resource investment.

One of the aspects of the acquisition process in which inherent risk has always been high is provisioning. It is logical to extend this cultural change to the provisioning arena.

Provisioning is defined by DOD 4140.1-R, *Materiel Management Regulation*, as:

> The management process of determining and acquiring the range and quantity of support items necessary to operate and maintain an end item of materiel for an initial period of service. (1:L20)

While DOD 4140.1-R is a rather recent document, this definition has been in use for over a generation. In actual practice, provisioning in the DOD has resolved itself into a discrete number of functional processes which, when properly implemented together, result in the fielding of initial organic support for a new system or piece of equipment. Although different sources provide different stratification of these functional processes, most will agree that they generically include:

(1) Initial supply support planning.
(2) Contracting for the development and delivery of logistics management data adequate to support the process.
(3) Contractor development of the technical data necessary to support the process.
(4) Government review of the data and finalization of the codification of levels-of-repair and inventory management decisions.
(5) Cataloging and standardization actions on new items identified as support items.
(6) Initial requirements determination computations for identified support based on the estimated maintenance, overhaul, and reliability factors developed by the contractor.
(7) Actual acquisition of initial items to provide support for an initial period of service.
(8) Design change management.

The detailed methodologies used to carry out these functions vary from program to program and from service to service, but the basic functions remain relatively constant. Figure 1 displays this generic process graphically.

The provisioning of spare and repair parts is still typically done under processes developed during the Cold War. Now that imperial communism has disintegrated, we have the opportunity to initiate changes to this process which will lead to greater efficiencies and provide more economical support to our future systems. One such change, as suggested by this proposal, would, in practice, eliminate traditional provisioning as the means by which initial spare parts are procured.

Historically, as suggested earlier, the driving force behind the provisioning effort was to have support available as soon as a system was fielded. As systems became increasingly complex, it became necessary to move many of the provisioning activities earlier and earlier in the acquisition process. Government materiel managers responding to this atmosphere of urgency were, in effect, forced to accelerate the provisioning process and to rely on data reflecting increasing levels of uncertainty, immaturity, and inaccuracy. This trend was clearly codified by the issuance of DOD Directive 4140.40, *Provisioning of End Items of Materiel*, in June 1983. That directive moved the beginning of the so-called formal provisioning process from the Production phase of the systems acquisition process back into the Full-Scale Engi-

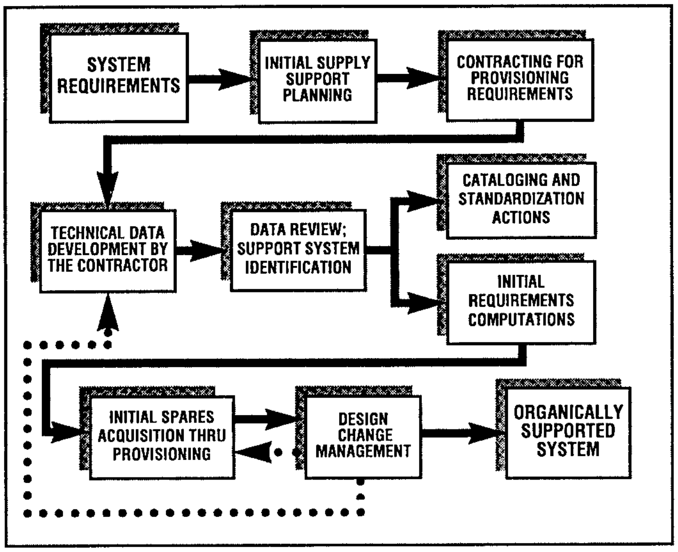

Figure 1. Typical Functions in the Provisioning Process.

neering Development (now known as the Engineering and Manufacturing Development) phase. To quote from that document:

> Planning for provisioning . . . will ensure that appropriate provisioning or Logistics Support Analysis (LSA) standards are cited in full-scale development (FSD) or production contracts or both. Provisioning requirements are included in the FSD contract, whenever possible. . . . The provisioning process will begin with the award of the FSD contract when an LSA, prescribed by MIL-STD 1388-1. . . is incorporated therein. (2:2)

What has been the impact of provisioning spares and other support items based on data developed earlier and earlier in the process? Exactly what anyone considering the process would expect. For one thing, DOD materiel managers have been forced to utilize less reliable logistics and program data, and this has translated into less accurate support system definition and less than optimum investments of available resources. In July 1988, the General Accounting Office (GAO) published a report on spares problems affecting the B-1B bomber. Among other things, they found:

> The Air Force has purchased millions of dollars of B-1B parts based on assumptions that have changed. . . . For example, the Air Force has or is ordering quantities of some parts based on low reliability when improvements to address the low reliability are completed or underway . . . Many of the defensive avionics system's parts already delivered are unusable or could be made unusable by the continuing development of the system. (6:5,37)

The actual acquisition of initial support is big business. Initial spares procurement for the B-1B was, according to the GAO, over $2.2 billion (FY88 dollars). Initial plans for sparing the C-17 aircraft also called for estimated expenditures of over $2.0 billion. Clearly, small percentage errors in computational factors will translate into the misallocation of tens, if not hundreds, of millions of dollars of taxpayer money in such cases. Yet, the *system*, as currently implemented in many cases, *ensures that such errors will occur.*

Another factor which affects initial sparing decisions is the move by DOD to base initial requirements computations on mathematical optimization models known as readiness-based sparing (RBS) models rather than the traditional demand-based methods used on most programs. (1:1-7) As we move to fully implement RBS technologies for initial requirements computations, the need for better input data will grow geometrically. Not only are such methodologies sensitive to variations in predicted demand and reliability data, they are equally sensitive to parts costs. By their very nature, provisioning prices must be estimates; no manufacturer can hope to quote realistic price data on a developmental item for which no firm order quantities or schedules have been developed. It should be painfully clear that both the demand data and the cost data currently used in the provisioning process are, at best, vague estimates during the engineering development and early production stages of system acquisition.

A second serious effect of early development and delivery of provisioning data is the massive effort necessary to manage the design change process. Modern systems could undergo thousands of design changes between the development and delivery of data and the stabilization of the system's production design. On the B-1B, for example, there were already 200,000 design change notices processed by 1988. For a typical month during the years 1987 and 1988, there were over 20,000 design change notices being processed. (6:30) This corresponds to an additional workload roughly equivalent to the regular provisioning effort for the system itself.

Time for a Change

What is to be done? If existing routine provisioning procedures lead to massive additional workloads and the potential misidentification of the initial support requirements for new developmental systems, and if a change to RBS computations threatens to increase the difficulties inherent in using estimated data, it would seem reasonable to acquire our initial spares under other procedures.

The obvious answer is to wait until we have a substantially stable design and actual demand data before we procure the support structure for the system. Support during the interim would have to be provided by the contractor or contractors involved in the development and production of the system. This idea was summed up very well in a statement attributed to then-Deputy Secretary of Defense David Packard in 1971:

> We are making decisions to acquire an organic logistics support capability for major weapon systems far too early in the acquisition process. . . . I see no reason why we can't rely on the contractor for such logistics support prior to design stabilization.

Historically, there proved to be reasons why we couldn't—most of them related to perceived mission needs and dollars. That option was simply not practical in an environment where we felt the need for organic support as we rushed systems into full-rate production while they were still undergoing engineering development. We could not afford the time or treasure necessary to develop demand data while contractors supported large-scale deployments of major systems.

That now appears to have changed. While the B-1B was a classic example of concurrency, ("Concurrency" is overlapping two or more phases of an acquisition program, such as the act of placing an item in production concurrent with its engineering development design while you build.) DODI 5000.2, *Defense Acquisition Management Policies and Procedures*, now calls for systems to have proven designs before entering full-rate production:

> [The] Milestone decision authority must. . . [e]nsure that the design is stable and producible and that production processes have been proofed. . . (5:3-23)

The common means of determining that a design is stable and producible is to place the system in low-rate initial production

(LRIP). The same source states that "[d]evelopment approval will typically involve low-rate initial production." (5:3-16) Placing a system in LRIP provides the opportunity to "get the bugs out" of the design and production processes prior to making a final full-rate production decision. It also provides an opportunity to develop actual demand data on the maturing design. If the development of provisioning data were delayed until adequate operational demand data were generated, that data would be significantly more accurate than that which has historically been available to materiel managers. This would not only reduce the enormous burden of effort currently expended on design change management within the provisioning process, but would also provide sufficiently accurate data for the use of RBS.

That is precisely what I am proposing: Delay the beginning of provisioning data development until the system is well into LRIP or, potentially, in the early stages of full-rate production. Then, accept incremental delivery of that data as the system matures and stabilizes. Projected demand and failure data, previously based on developmental engineering data, would then have the additional input of actual operational rates generated on reasonably stable designs. The gap in support caused by the delay of the development of organic capability would, of course, require the utilization of preplanned interim contractor support (ICS). The cost of this ICS should be more than offset by the savings and cost avoidances realized by more properly allocating spares procurement dollars.

The relatively small number of support items necessary to support the LRIP period and initial full-rate production period would be identified by the contractor who would be responsible for their maintenance and configuration management. As the system is gradually phased to organic support, the government would accept those initial spares only up to levels determined by then-current requirements computations. This would ensure that the contractor would not use its position to "inflate" spares sales to the government. In the relatively unlikely event that the contractor had acquired or produced excess items, it would have to absorb that cost itself rather than pass it on to the government. (As an aside, considerable research in recent years has suggested that contractor-determined initial spares recommendations are at least as accurate as those determined by the government, if not substantially more accurate.)

Once provisioning data now containing actual demand data is available on each item, requirements for that item should be determined utilizing normal replenishment procedures, and that item should be acquired though normal procurement procedures. This change would free the government of many of the problems inherent in the current provisioned item order process and increase the probability of competitive breakout and other cost-saving measures. This procedure would also force spares for our new systems to compete for funding with existing systems, providing the government the opportunity to optimize the expenditure of increasingly scarce spares money. In addition, it would be consistent with the spirit of DOD 4140.1-R which calls for provisioning requirements to be computed with methodologies compatible with those used for replenishment. (1:1-7)

Item entry would be accomplished incrementally as the contractor-identified support items for use during the ICS period. Any additional items requiring cataloging action would be processed as the provisioning data were delivered. The proposed process is graphically illustrated in Figure 2.

None of these suggestions are new; many groups and individuals have suggested similar changes over the last decade. In 1990, the Department of Defense Provisioning Process

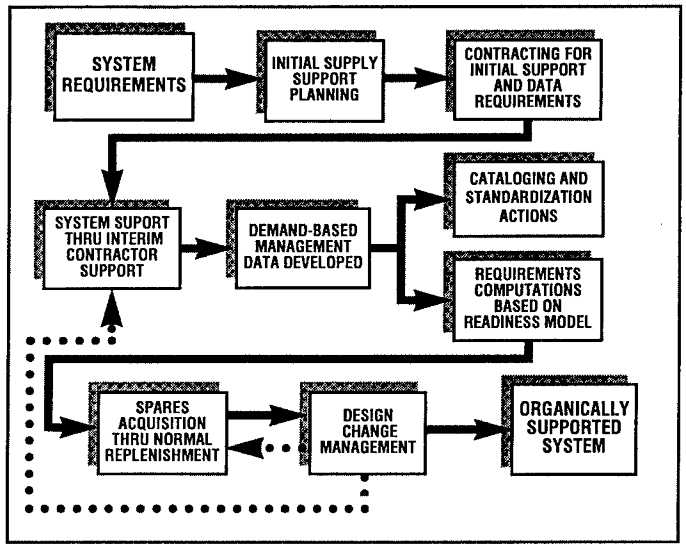

Figure 2. Recommended Initial Supply Support Process.

Review Study Report issued by the Office of the Assistant Secretary of Defense (Production and Logistics) stated:

> . . . [I]t is the consensus of the task group that especially on highly complex, developmental weapon systems, the preferred initial support alternative, is some form of 'preorganic support'. . . An obvious alternative to a forced organic capability is reliance on contractor support approaches . . . This recommendation is not new. In fact, it is largely an adoption of the traditional interim contractor support (ICS) approach. . . . (7:2-7, 2-10)

Why, then, aren't we typically provisioning systems under procedures like this? The long-established root problem has been that the basic philosophical structure overarching the acquisition process. That philosophy prevented managers from implementing these options which would, despite any other potential benefits or problems, delay the fielding of fully, organically supported systems. I have served on numerous process action teams and other working groups related to provisioning on major Air Force systems over the last several years, and the one thing which has most impressed me is the sense of urgency that most of those working in the discipline exhibit for providing robust organic support as early as possible. Costs, waste, and workload take a clear backseat in their minds to providing a vigorous support structure to the customer.

This attitude was once explained to me by a practitioner as an application of the "bridge principle." This principle compares provisioning to building a bridge over a one hundred-foot-wide canyon. If you should happen to build a one hundred and one-foot-long bridge, no one cares. If you should happen to build a ninety-nine-foot-long bridge, everyone from the Congress on down wants to meet you personally. In direct application to provisioning, it translates into making overly conservative (plentiful) stockage decisions and making those decisions much too early in the process to have any hope of accuracy.

This mindset is hard to break. Even in DODI 5000.2, the document which implements the cultural changes in acquisition philosophy to which I earlier referred, the prejudice against delaying organic support is evident:

> Program managers should seek to structure their programs such that interim contractor support will not be required. (5:7-A-3)

(Continued on bottom of page 10)

Logistics Test: A New Dimension for Test and Evaluation

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Major Mary H. Parker, USAF

Logistics Test, or "Log Test," has been conducted at Edwards Air Force Base for as long as there has been flight test. However, it has not been widely recognized due to lack of formal structure, formal documentation, and publicity. Our recent efforts with Logistics Test, within the 412 Test Wing (TW), seek to remedy this situation. This paper will explore the foundations of the Log Test concept, examine the methodology the C-17 Combined Test Force (CTF)* utilized for Log Test, and describe examples where Log Test has influenced the design of the B-2, C-17, and F-22.

Introduction

In basic terms, Logistics Test is getting the end users—the maintainers—involved in the acquisition of weapons systems. As they perform maintenance on the aircraft, missiles, or equipment during test and evaluation (T&E), they are evaluating the practicality of the design for supportability and maintainability. In Log Test we listen to their evaluations and suggestions so we can incorporate or "design-in" these supportability and maintainability aspects into the weapons system before it goes into production. This concept of designing for logistics support does have precedence. Volume II, Essay Y of AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force*, states:

> The best aerospace weapons systems are worthless if they cannot be refueled, rearmed, and otherwise kept in commission. Aircraft grounded for lack of parts or consumables represent, for the period they are out of service, as much loss to combat capability as aircraft destroyed by enemy action. Aircraft that require excessive maintenance or excessive time to accomplish routine maintenance reduce combat availability, and, in effect, add to the attrition toll.
>
> The most obvious solution to the maintenance challenge is to give logistical requirements high priority in designing aerospace systems. Systems designed for easy maintenance and greater reliability decrease the logistics problem. (2:255)

The 412 TW approach to Log Test borrows heavily from the definition of Integrated Logistics Support (ILS) in DODI 5000.2, *Defense Acquisition Management Ploicies and Procedures*. ILS is a "disciplined, unified, and iterative approach," to weapons system acquisition and is comprised of ten elements: (3:7-A-1)

(1) Maintenance Planning
(2) Manpower and Personnel
(3) Supply Support
(4) Computer Resources Support
(5) Facilities
(6) Design Interface
(7) Technical Data
(8) Training and Training Support
(9) Support Equipment
(10) Packaging, Handling, Storage, & Transportation

The 412 TW approach is equally disciplined, meaning that we have a structured approach and systematically assess all ten ILS elements. It is unified, which implies we understand that the ten elements are not separate and distinct, but inseparable, interrelated to each other and to the end item they support. Our approach is also iterative, meaning we assess each element over time, as the design of the weapons system evolves and matures, and as the logistics support system is developed. Our maintainers routinely work with many of the ten elements of ILS as they perform maintenance on the weapons systems. For example:

SCENARIO	ILS ELEMENT
Amn S. Eagle uses	Manpower and Personnel
T.O.12R2-2ARC164-8-1	Technical Data
to conduct an operational check on the UHF Have Quick Radio	Maintenance Planning
using Mobile Electronic Test Set (METS)	Support Equipment
and replaces a defective synthesizer section.	Supply Support

Log Test is a test methodology, criteria, and tool for evaluating and analyzing the ten ILS elements as they apply to the article under test. The objective is to influence design through the application of the ILS elements as early as possible in the acquisition cycle. Log Test integrates the evaluation and analysis efforts of Reliability & Maintainability (R&M), Human Factors (HF) engineering, and Logistics Test (LT), and is an integral part of the Development Test and Evaluation (DT&E) process. Recognizing that we test to get information for decision makers, our test results are forwarded for the appropriate tradeoffs and decisions to be made.

Each of the CTFs at Edwards has its own tailored approach to Log Test and it is program specific. The B-2 Program was the first to embrace this concept of Log Test and has documented numerous success stories. Our Logistics Test participation during the demonstration/validation (DEM/VAL) phase of the F-22 Program was another first. This was the earliest documentation of Log Test in an acquisition program—94 watch items were submitted to the F-22 System Program Office (SPO). Again, we were able to reap some dividends from Log Test and influence the design to incorporate supportability and maintainability aspects.

The underlying premise for Log Test is that experienced maintainers have good ideas. They may not know the book definition of ILS, but they know what works and what doesn't based on gut feel and busted knuckles from operational experience. Our emphasis on Logistics Test seeks to formalize the process to systematically tap these good ideas.

* A CTF is an integrated Test and Evaluation product team that is empowered to evaluate a weapon system and/or hardware and software by collocating its major members at one primary test site and integrating their requirements in a manner to execute combined test planning, provisioning, execution, and data acquistion/production, while meeting independent analyses/reporting. (1)

With this paper, we will focus on the methodology utilized by the C-17 CTF with their Data Analysis Plan (DAP).

C-17 Data Analysis Plan

The C-17 Logistics Test Plan established the framework for logistics test accomplishment and the philosophy behind evaluating the ten ILS elements during DT&E. The DAP goes a step further and identifies the methodology, success criteria, and tools to be used during the analysis and reporting on the ten ILS elements evaluated under the C-17 Logistics Test Plan. The C-17 System Specification established guidelines for design of the aircraft, and in several cases, tied specification requirements to the ILS elements. For example, paragraph 3.7.2 from the C-17 Systems Specification states:

> Support Equipment. Support Equipment functional characteristics, in addition to those specified herein, shall be specified in the SE General specification and SE item specification. The SE shall provide the operational support capability necessary for the weapons system to meet its performance, availability, alert, turnaround, and maintainability requirements specified herein. This support capability shall be provided within the constraints of the deployment and maintenance concepts specified herein and Air Force personnel capabilities. (4:45)

System specification statements like this provided the basis for developing the Logistics Test questionnaires used to collect data for analysis and reporting. The questionnaires expand on the general information provided in the system specification and enable analysts to pinpoint deficiencies to the specific aircraft system, component, or task.

The DAP represents a significant step in the development of Logistics Test as a recognized discipline (along with Reliability and Maintainability engineering, and Human Factors engineering), and further legitimizes Logistics Engineering (LE); designing logistics into emerging weapon systems early in their acquisition life cycle. Though analysis and reporting could have been completed without a DAP being written, the C-17 CTF elected to document, as completely as possible, the development of Logistics Test.

Structure

The DAP contains three sections. Section 1 contains an introduction to the organization of the DAP and the concept behind using the ten ILS elements as the basis for accomplishing Logistics Test evaluations.

Section 2 details the Logistics Test Measures (LTMs) for each of the ten ILS elements evaluated and gives a description of how each discipline (Reliability & Maintainability, Human Factors, and Logistics Test) intended to collect data for analysis and reporting on the ten ILS elements. Specific definitions of each LTM are presented, stating exactly which aspects of each LTM were being examined and reported on.

Section 3 is organized according to the ten ILS elements, detailing the methodology used by each discipline for evaluating the LTMs. Section 3 is the heart of the DAP. This section contains the formulas, statistical methodology, evaluation criteria, and rating systems used by each discipline for Logistics Test reporting.

Appendix A of the DAP lists the various reference documents used during development of the DAP. Appendices B and C contain the questionnaires given to maintenance personnel. Results from these questionnaires were loaded into a database for statistical analysis and reporting on all ten ILS elements.

Figure 1 shows the breakdown of the Logistics Test Measures across the three disciplines involved in conducting and reporting on C-17 Logistics Test. There is some overlap among the disciplines in the specific methodology applied to collecting and analyzing data for certain Logistics Test Measures; for example, the Crew Size and Air Force Specialty Code (AFSC) LTMs under the Manpower and Personnel ILS element. Though the LTMs are the same, the approach used by the two disciplines is different based upon the data collected and the analysis performed. These differences provide for a broad-based analysis of Logistics Test data across the three disciplines.

Data Collection/Analysis

The most significant difference among the three disciplines in conducting C-17 Logistics Test results was in the area of data collection and analysis. The data collection and reporting process is diagrammed in Figure 2.

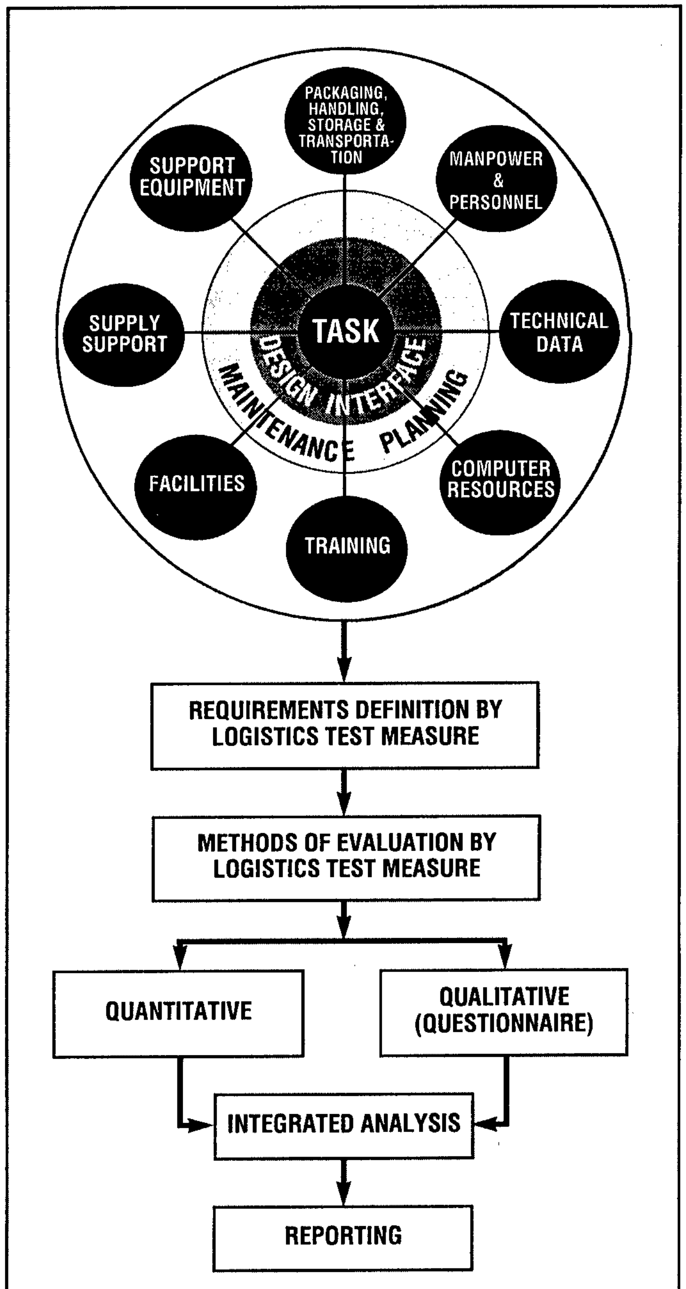

Figure 2. Data Analysis Plan Flow.

ILS Elements	Reliability & Maintainability	Human Factors	Logistics Test
Maintenance Planning	Reliability Mean Time Between Maintenance (Inherent) - MTBM (I) Mean Time Between Maintenance (Corrective) - MTBM (C) Mean Time Between Removal - MTBR Maintainability Maintenance Manhour per Flight Hour - MMH/FH Mean Manhours to Repair - MMTR		Scope Frequency Task Time
Manpower and Personnel	Reliability Maintainability Crew Size Air Force Specialty Code - AFSC	Human Performance	Crew Size Air Force Specialty Code - AFSC
Support Equipment		Ease of Use Handling Safety Compatibility	Supportability Utilization Rate
Supply Support	Reliability		Source, Maintenance, Recoverability (SMR) Coding Availability
Technical Data		Safety Adequacy Clarity of Instructions	Understandability Ease of Use
Training and Training Support			Knowledge Training Type 1 Knowledge Training Type 4 Proficiency Training Safety
Computer Resources	Reliability Maintainability Built-in Test (BIT) System Adequacy	Functional Utility Ease of Use	Functional Utility Ease of Use
Facilities			Supportability Safety Compatibility
Packaging, Handling Storage, and Transportation			Suitability Safety
Design Interface	Reliability Maintainability	Interoperability Accessibility	Energy Consumption Accessibility System/Component Preservation Component Standardization

Figure 1. Logistics Test Measures.

R&M engineering utilized quantitative data for its analysis and reporting on each of the LTMs in the DAP. The approach is very concrete and objective. The data gathered were compared against the R&M growth projections for each system at the specified C-17 fleet flying hour milestone being reported. Data indicating that the aircraft system being analyzed met or exceeded the projected reliability or maintainability values meant that the system's performance was Satisfactory. Aircraft systems whose data was below the projection but had a maturity growth curve that indicated a high probability of achieving the projected reliability or maintainability were considered Marginal. Systems that were below the projected growth and showed a maturity curve that indicated it would not achieve its projected reliability or maintainability values were deemed Unsatisfactory. R&M data included in the Test Results Sheets were reported by exception. Data that appeared unsatisfactory were selected for in-depth analysis and reporting. Emphasis was placed on items that were listed as the top 25 inherent failures and maintenance man-hour consumers.

Data for R&M evaluations were collected using the AFSC Form 258, Maintenance Discrepancy/Production Credit Record. The form facilitates collection of maintenance and repair data, including but not limited to: Job Control Number, Workcenter, Flight Hours, When Discovered, How Malfunctioned, Action

Taken, Work Unit Codes, Item Part and Serial Numbers, Maintenance Crew Sizes, AFSCs, Task Times, Discrepancy Being Worked, and Corrective Actions. This data were then loaded into the System Effectiveness Data System (SEDS), a COBOL-based computer database for tracking and analysis of reliability and maintainability data.

Data for both Human Factors and Logistics Test reporting were collected using questionnaires. The questionnaires were developed using the "Six-Point Adequacy Scale" derived from the US Army Research Institute for the Behavioral and Social Sciences, *Questionnaire Construction Manual*, dated June 1989. This evaluation concept was agreed upon during development of the C-17 Logistics Test Plan. The six-point scale yielded both numerical data for statistical analysis and six adjective ratings (6=Highly Adequate, 5=Moderately Adequate, 4=Slightly Adequate, 3=Slightly Inadequate, 2=Moderately Inadequate, 1= Highly Inadequate) for use in describing the subjective data collected from the questionnaires.

Maintenance personnel completed the questionnaires after accomplishing specific maintenance tasks. Human Factors data were provided for all Detailed Test Information Sheet (DTIS) test points and on any tasks that maintenance personnel identified as having negative human factors impacts. Logistics Test data were initially required only on DTIS test points. However, during a management review and analysis of data that had been collected prior to 1 January 1993, data quality and quantity were determined to be less than adequate for performing meaningful analysis and reporting of Logistics Test events (this was actually the birth of the DAP). Subsequently, the Logistics Test questionnaires and associated annexes were rewritten, the DAP was initiated, and data collection was required for all tasks performed by Air Force DT&E maintenance personnel. Existing data were reviewed and updated using the new questionnaires. Without a DAP, data collection and reporting had remained relatively undefined. The validity of Logistics Test reporting was in jeopardy. Within three months, the questionnaires had been rewritten, the DAP had been agreed upon by the contributing disciplines, and data collection was back on track. The DAP had provided the necessary framework to allow Logistics Test data collection, analysis, and reporting to proceed.

With the establishment of new data collection procedures, several closed-loop information management systems were required. Logistics Test questionnaires were now identifying problems among the ten ILS elements being evaluated. However, without initiating corrective actions, Logistics Test was only doing part of the job. Closed-loop systems were developed to cause the initiation of Product Quality Deficiency Reports (PQDRs) and Publication Change Requests (PCRs) to correct problems identified during evaluations. Logistics Test questionnaires that had ratings of "4=Mildly Adequate" or less were examined to determine if corrective actions needed to be initiated. The closed-loop systems allowed constant monitoring of Logistics Test inputs prior to the analysis and reporting of the data. This elevated aircraft system problems to the SPO for timely initiation of corrective actions.

As a result of the DAP and changes to Logistics Test data collection procedures, the Logistics Test Management System (LTMS) was created. The LTMS was an integrated group of computer programs used to track, analyze, and report on Logistics Test data and events. The system has grown into what is now LTMS II, a highly efficient data management system that provides daily maintenance status, scheduling information, R&M data, PQDR status, fleet flying hour information, and a myriad of information at the fingertips of all C-17 CTF managers. LTMS II is the first integrated Logistics Test database system ever developed to further Logistics Test data collection, analysis, and reporting. Developed by Computer Sciences Corporation, LTMS II is being refined for use in other acquisition programs including the F-22 Advanced Tactical Fighter.

Reporting

Reporting was done in two distinct phases: Test Results Sheets and Technical Reports. The Test Results Sheets were interim reports used to release capability to the using command. They were completed and released in blocks as the C-17 aircraft's capability matured. Initial Test Result Sheets lacked inputs from the R&M engineering discipline due to the inflexibility of the COBOL-based SEDS system which resulted in excessive data processing and analysis times that had not been anticipated during development of the DAP. These problems have been corrected through changes in data processing and analysis techniques. The C-17 CTF is currently preparing to publish the final Technical Reports for Logistics Test.

Analysis and reporting of Logistics Test results was conducted in accordance with the guidance established in the DAP. The DAP was written to allow flexibility in the reporting of Logistics Test results. Each discipline was given the freedom to report their data within the framework of the *Air Force Flight Test Center Report Writing Guide*. This freedom resulted in some confusion among readers of the initial Test Result Sheets, and a standard rating system was later developed for reporting of results. Reporting has since become more integrated and uniform, eliminating the differences evident in early reports.

Lessons Learned

The most important lesson learned regarding Logistics Test data collection and reporting was that a DAP needs to be incorporated into the Logistics Test Plan, and that both need to be put on contract for any future acquisition program. This will formally establish the framework for Logistics Test evaluation, data collection, and reporting for the program. Without this critical guidance, Logistics Test efforts will be ineffective at identifying specific problems and targeting areas for correction. In addition, the Logistics Test Plan must define the specific responsibilities for all concerned parties to include DTIS accomplishment, evaluation procedures, success criteria, corrective action procedures, and reporting.

During accomplishment of C-17 Logistics Test evaluations, it became apparent that certain ILS elements did not lend themselves to evaluation by maintenance personnel, specifically, Packaging, Handling, Storage & Transportation (PHS&T) and Supply Support. Maintenance personnel are ill-equipped to properly evaluate these elements. The best solution to the problem is to integrate supply personnel into the Logistics Test effort. This would enable accurate tracking of supply lead times, consumption, PHS&T practices, recommended storage area requirements, establishment of needed spares, and a variety of other supply-related issues that are often transparent to maintenance personnel. In addition, an item-by-item evaluation of source, maintenance, and recoverability (SMR) coding adequacy should be performed by supply personnel as part of the Logistics Test evaluation process for all components ordered through the Supply system. Maintenance personnel often do not have the background to assess the information relating to SMR coding.

Finally, the structure of evaluating the ten ILS elements for Logistics Test should be revisited. The iterative nature of the structure of the elements causes a significant amount of confusion at all levels during Logistics Test analysis and reporting. Though the elements do properly interrelate, Logistics Test evaluation of the elements is extremely difficult when attempting to address these interrelationships. For instance, evaluating all the sub-elements of Design Interface is nearly impossible for personnel performing Logistics Test evaluations on any maintenance task.

Logistics Test Success Stories

The following stories illustrate how Log Test has impacted the design of our weapons systems:

B-2 Aft Avionics Bay Access

As the front of the aircraft filled up with Line Replaceable Units (LRUs) during the design, a number of major LRUs were put into an aft avionics bay. Access to this bay was proposed through an access hole, using a newly designed overhead hoist to remove and replace components through the hole. Maintenance personnel immediately saw that this was going to be a difficult, time-consuming procedure—working overhead and not being able to see what they were doing on LRUs as heavy as 80 pounds. Since this was found by the maintainers on the aircraft mock-up, there was adequate time for redesign of this area. As a result, an access hatch was designed so that maintenance personnel can climb into the bay area to work. Additionally, a new item of support equipment was not needed, since the new design allowed the use of a B-1 hoist, already planned for use in another area on the B-2.

B-2 Aircraft Power Receptacle

The aircraft external power receptacle could not be mounted externally on the aircraft due to stealth requirements. Consequently, it was put in the crew entrance door area. The receptacle was installed parallel to the ground, facing out toward the aircraft wing tip. When a power cord was plugged in, the weight of the plug and cord put a strain on the receptacle, cracking it out of the mount and "smoking" on several occasions. The maintainers proposed that it be rotated 90 degrees so that the cable went into the receptacle vertically. This allowed the cable to lay on the edge of the crew entrance door for support and took the weight off the receptacle. This was done for the flight test aircraft. The plan for production is to move the receptacle four feet lower and reorient it so that there is less stress on the receptacle and minimize the cord chafing on the door.

B-2 Component Positioning Trailer

This is a multi-use trailer designed to transport and position major flight control components, as well as a variety of LRUs. As built by the contractor, it was massive and had four independently swiveling wheels with pneumatic tires. Maintainers had a lot of trouble pushing it around and positioning it on pneumatic tires because of its weight. Due to their input, the trailer was redesigned to use hard rubber casters, making it much easier to push. The new design also incorporated a towbar-type steerable front axle for maximum flexibility in positioning the unit.

B-2 Egress Hatch

An egress technician for the B-2 Program saw a problem with the maintenance procedures for the ejection hatches—it took a two-man team 214 hours to do this job! His idea was to replace the 243 hi-lock fasteners with screws and nut-plates, allowing for faster removal or installation of the screws. The engineers said this would not work because these are stress panels—but other aircraft have screws and nut-plates securing their stress panels. Nevertheless, the technician pressed the issue and when the changes were incorporated, the system was tested and declared safe. The result was a 92% reduction (from 214 hours to only 18 hours) in maintenance time.

C-17 Liquid Oxygen (LOX) Servicing

In 1989, while exploring a design/development fixture (wooden mock-up) at the Long Beach manufacturing facility, a maintenance technician discovered the hardware used to secure the LOX servicing connection was installed backwards (nut and bolt protruding vice screw installed flush with bulkhead). Investigation revealed this was per design. However, with the fasteners facing outward, the LOX cart servicing connector would not seat. The contractor revised the design.

C-17 Main Landing Gear Down Lock Pins

It was discovered that the pins did not fit securely in the down lock link. During maintenance, the pins could be dislodged and present an unsafe condition. The contractor redesigned the pins.

C-17 Slat (Leading Edge Flaps) Hoisting Provisions

During a slat change, evaluators discovered the required crane would not reach a sufficient height to safely accomplish the task. Additionally, the hoisting sling was not marked for center of gravity—critical to allowing proper removal and installation of large aircraft components. The contractor reworked the Support Equipment Recommendation Data (SERDs), proposed a different crane, and changed the drawings to mark the sling.

C-17 Cargo Compartment Under-Floor Access Safety Hatch

During evaluation of under-floor access, evaluators discovered the safety grate used to prevent falls did not fit flush with the floor, creating a tripping hazard right inside the crew door. This item is being monitored by the SPO in order to assess the corrective action required.

F-22 Avionics AFSC

This is an example of our impact on manpower and personnel as an ILS element. Headquarters Air Combat Command (ACC) decided to use F-15 avionics AFSCs for the Advanced Tactical Fighter (ATF). As a result of our experience during the DEM/VAL, we recommended to ACC that they change the integrated avionics flight control AFSC from F-15 to F-16, because of more commonality in skills. The Air Force Military Personnel Center concurred with changing the AFSC for our authorization here at Edwards, and ACC is seriously evaluating the proposal.

F-22 Horizontal Stabilizer Bearings

During the DEM/VAL phase of the ATF Program, it was necessary to remove and reinstall the horizontal stabilizers. The stabilizer bearings are installed using a procedure which requires them to be shrunk to fit, then positioned in the aircraft frame. As a field-level procedure to remove and replace stabilizers, this would require maintenance units to have access to liquid nitrogen or dry ice. Additionally, the bearings are difficult to remove without damaging them. We recommended a more cost-effective and efficient method similar to the F-15 & F-16 design. This method allows bearing removal and installation using a locking tab instead of shrinking the bearing.

F-22 Engine

Pratt & Whitney held a maintainability and design conference on proposed configurations for the Engineering and Manufacturing Development (EMD) aircraft. At this conference was a maintainability demonstration using a mock-up of the aircraft and the proposed engine mounting system. Air Force personnel donned chemical gear and performed removal and installation of the proposed designs in an attempt to discover potential problems. Data gathered will be used to design the mounting system and airframe/engine interface to insure maintenance can be done under the most austere conditions.

F-22 Hush House Compatibility

As part of the DEM/VAL phase for the ATF, we were required to evaluate the compatibility of the ATF with the standard hush house—would the vectoring exhaust nozzles and additional thrust pose a problem, or would the ATF be able to use the hush house? We found that there is a limit to the degree of nozzle deflection that the hush house can accommodate (12 degrees) before the thrust of the engine is diverted outside the deflection area. If a need arises to exceed the 12-degree limit, the procedure must be conducted on an outdoor trim pad.

Summary

With dwindling defense budgets, drastic manpower cutbacks, and the move toward a streamlined acquisition process, the US Air Force and Department of Defense as a whole can ill afford to put logistics considerations on the tail end of the design process. Logistics support criteria need to be examined during the initial stages (Concept Exploration) of the acquisition process and throughout the other phases of acquisition (DEM/VAL and Engineering and Manufacturing Development) prior to the production decision. Logistics Test is a structured approach to ensure that supportable weapons systems will meet the needs of our military force.

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(Continued from page 4)

I contend that the recent and historical changes in the international situation have opened a window of opportunity for the immediate implementation of basic changes in how we support new, developmental systems. DOD policies and directives need to be instituted which clearly require the shifts in the provisioning process recommended here. If they don't make these changes mandatory, it is quite likely that the bridge builders will not change their ways.

Summary

Now that we are not living in constant fear of general war, there is no justification for the misapplication of massive amounts of federal treasure (treasure ultimately financed by national indebtedness) in support of the initial sparing of new weapon systems. As long as we generally plan to require LRIP on our new, developmental systems, we should plan to delay the acquisition of the initial support for those systems as long as possible to allow the development of significantly more mature management data and the generation of actual demand data on individual line items. This will allow us to skip the initial acquisition of support items based solely on grossly inaccurate management estimate, allow the effective use of the same computational models for initial requirements as we use for replenishment computations, and provide a significantly more optimal support structure for the system once it is fully fielded and supported.

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CAREER AND PERSONNEL INFORMATION

Civilian Career Management

Logistics Civilian Career Enhancement Program (LCCEP)

The LCCEP located in the Air Force Civilian Personnel Management Center, Randolph AFB, Texas, implemented the use of a Whole Person Score (WPS) in November 1992. The score is used to identify eligible career program registrants for competitive placement and career development opportunities. LCCEP covers some 3,800 positions worldwide, at General Schedule grades 9 through 15 (GS-9s/10s are covered in the transportation series only), representing 17 primary series and 4 series shared with other career programs. The differentiating factor between the shared series is the logistics skill codes allocated to a position. LCCEP is the source for competitive placement certificates for the covered positions and, in this regard, serves as an extension of the respective serving Civilian Personnel Flight.

The WPS has been in use for a little over two years and is currently being used for competitive actions, such as promotions, reassignments, and career development opportunities. The LCCEP Policy Council has approved two very positive changes for implementation effective with the FY94 Assessment Cycle for use in FY95 and subsequent year competitive placement and career development opportunities.

First, the total points for the Assessment element remain at 200; however, the Interview now has a maximum value of 120 points, and the Behavior Inventory has a maximum value of 80 points vice 60 points and 140 points, respectively. The Interview point reallocation recognizes the control a registrant possesses in answering the questions during the interview process. The new scoring methodology was effective as of 30 November 1994.

Second, the minimum grade level at which experience points are credited was dropped from General Schedule grade 11 and Wage Supervisor equivalent, to General Schedule grade 9 and Wage Supervisor equivalent. This is of tremendous benefit to the registrants as it broadens the experience base for which points are credited under the WPS computation. The planned implementation date is February 1995. This date is dependent on a change to our data system.

Consequently, the four elements of the Whole Person Score and their corresponding point values are now as follows:

Professional Experience	80
Education and Training	80
Performance Appraisal	100
*Assessment	200
	(Interview 120/Behavior Inventory 80)

* Pertains only to registrants eligible for promotion to General Schedule grades 14 and 15. Generally, these are GS-13 and 14 registrants.

The bottom line of these changes is the registrant is provided with greater input to the total Whole Person Score achieved, and the assessment instruments are more equitably weighted in the process.

(Hugh G. Lovelady, AFCPMC/DPCL, DSN 487-4087)

Logistics Professional Development

Consolidation at Air Force Military Personnel Center (AFMPC)

There is a growing trend in the Air Force to have "logistics" officers opposed to the traditional supply, transportation, logistics plans, and maintenance officers. To help facilitate this movement, all of the Logistic Support Officer Assignments personnel will be moving. No, we are not leaving sunny San Antonio, but we will be consolidating into one location within AFMPC. Presently, we are not located in the immediate proximity of one another. This situation makes working logistics cross flows a bit complex. Sometime after the first of the calendar year we will move to a central area. This move will not change our phone numbers or e-mail addresses, but it will greatly improve our ability to work cross flows.

Cross Flow Opportunities

We are working hard to simplify the process and to allow officers the opportunity to cross flow to other logistics fields. As you may have noticed, we are now advertising positions that are able to accept cross flows on all of the logistics fields Electronic Bulletin Boards (EBBs). These are positions that the gaining unit and the MAJCOM have agreed would be great learning positions for officers desiring to career broaden. These positions will be treated the same as other positions advertised on the EBB. Positions will be advertised for 30 days, and AFMPC will make the selection at the end of that time frame.

Another potential cross flow opportunity available is through the AFIT in-residence master's degree program. An officer can now apply for an AFIT master's program in another logistics field. If selected, the officer will be assigned to that particular career field for a three-year tour upon graduation. This is an ideal avenue to complete a master's program and to gain a cross flow assignment as well.

Perhaps the easiest method to cross flow is to obtain a Permanent Change of Assignment (PCA) on the base where one is presently assigned. This can be accomplished by working through one's commander and the Operations and Logistics Group Commanders. While this can be a simple process, it is important to not present an impression of "homesteading" at that base.

(Major Toby J. Seiberlich, AFMPC/DPMRSL, DSN 487-4024)

Reliability and Maintainability: A Common Ground for Cooperation

Captain John P. Laverdure, USAF
Thomas J. Howard

Introduction

Except for flight critical systems and safety, the commercial aircraft manufacturers and the airlines have not placed much emphasis on reliability and maintainability (R&M). When they did include reliability, it was mainly in the form of redundant systems rather than more robust and reliable parts. With a worldwide economic slowdown and a declining defense budget, both the commercial airline industry and the Department of Defense (DOD) have been forced to rethink how they do business and take a closer look at R&M. The DOD, particularly the United States Air Force (USAF), are in the midst of lean budget years forcing them to look at ways of extending the life of existing aircraft and reducing support costs. Reliability, maintainability, supportability, and deployability are now on a par with performance. The commercial airlines are also in the midst of an R&M revolution as well. The ability to have reliable aircraft successfully meet scheduled departures is now a key competitive and revenue-generating advantage for an airline. Maintainability, the ability to return an aircraft to working order, is also of great concern. A delay due to repair, is still a delay that costs money and customers. Additionally, both the airlines and the USAF operate older and aging aircraft with many like systems. Therefore, they both need to do things smarter to make their systems more cost effective.

In this paper we will discuss how the mission can be performed smarter and more efficiently, whether it be flying a support mission over Iraq or the 7:00 a.m. flight from Chicago to Los Angeles. First, we need to set the stage describing how we arrived at this phase and the current operating procedures. From here we can take a look at what improvements are needed and where they can be made. The big area here is "Dual Use" technologies. Dual Use technologies have both a commercial and a military purpose. Next we will cover reliability. Here we want to find out what problems the airline industry are facing and how cooperation between the government and industry can solve these. Finally, we will address maintainability. We will identify how the fleets are maintained and will recommend improvements. Overall, we will prioritize and categorize these technologies to identify which ones need to be tackled first. By taking such a structured approach to the identification of problems and possible solutions, we can recommend an approach that could result in improved operation of the civilian and military aircraft fleets.

Background

In 1978, the United States government passed a law which ended 40 years of domestic air transportation regulation. The objective was to create opportunities for the airlines to become more competitive by improving service and reducing costs. (1) The results of this law led the airlines to change their thinking on letting the balance sheet and bottom line dictate routes, scheduling, service, pricing, and expansion efforts. (2:41) This in turn has led to a disparity in the price of fares versus the distance traveled—better known as a "fare war." In high competitive areas, fares have remained low as compared with the low competitive areas where fares have more than doubled to pick up the slack. These fare wars have even resulted in destructive competition by generating more capacity than the area can sustain thus eliminating smaller, less stable airlines. (3)

Another aspect of deregulation has been the shift to a greater use of hub and spoke operations resulting in more congested airports. This increase in traffic created problems as the government failed to provide additional air traffic controllers and airport capacity. (1) These problems were further enhanced by the Professional Air Traffic Controllers Organization (PATCO) strike of 1982, where all striking air traffic controllers were fired for refusing to return to work. The impact of the strike resulted in the airlines limiting the amount of service they can provide to their customers in the hub and spoke operation and constricted their expansion and growth efforts.

In today's competitive airline industry, the number one concern is no longer fuel costs and efficiency, but the cost of operating, maintaining, and supporting the various aircraft fleets. (The same is true for the DOD as can be seen by the Air Force's desire to eliminate base-level repair shops under their two-level maintenance concept.) To remain competitive, many US airlines and commercial operators are restructuring to reduce costs in order to reduce fares. A few have even gone into Chapter 11 bankruptcy court to permit them to restructure their debt and remain in operation. Others have responded by offering company ownership to their employees in exchange for salary concessions. Both Northwest and United Airlines are recent examples of this in negotiating their current union contracts. Additionally, they are, when possible, retiring aircraft from their fleet and eliminating routes to reduce costs. The result of this series of events and reactions is the airlines are operating on the verge of bankruptcy. In addition, each unscheduled delay or cancellation of a flight due to maintenance costs money and causes customer dissatisfaction. The financial impact of this, according to *Aviation Week and Space Technology*, was a $1.9 billion loss across the industry in 1992. (2:44)

A by-product of this competitiveness is the fact that airlines are keeping older aircraft in operation longer, since there is no money available from revenue to invest in newer aircraft. This lack of new aircraft purchases trickles down to the aerospace industry causing an additional financial burden in addition to the DOD drawdown. The combination of these two actions is causing layoffs at the different aircraft manufacturers and their vendors.

In spite of the turmoil, overall, the objective of deregulation has been met. The future of the airline industry will depend on the economy and how the airlines react to change.

DOD and USAF

So where can the DOD and USAF help? Are there areas where DOD is developing or should be developing different maintenance capabilities to benefit both the government and the airline industry? The answers to these questions will point us in the direction of where we want to develop Dual Use technologies. They also help us prioritize the technologies to provide the most benefit to industry. An example of this, as stated by the airlines, is the need for diagnostic systems which allow them to turn an aircraft quickly and minimize schedule interruptions. (4) This becomes very important when the aircraft is away from its home base and requires fault isolation and diagnostics. The Air Force faces the same problem when it deploys to an austere location. The equipment required to provide support must enable the maintainer the capability to keep these planes operating and the mission moving. In combat, this could mean life or death, whereas for the airlines, this means survival in a very competitive industry. By developing good reliability and maintainability practices, the airlines and the military will be able to reduce costs and become more efficient.

Dual Use

With the arrival of a new administration in Washington DC, a new set of buzzwords have been circulating around DOD agencies: "Dual Use" technologies and "Defense Conversion." The idea behind these buzzwords centers on directing DOD agencies to assist the civilian economy with the conversion from DOD-related products to commercial applications or products. How big will this Dual Use initiative be? If reports are correct, by 1998 over 50% of the federal research and development (R&D) budget will be directed solely toward Dual Use projects. (5) Industry's reaction to this has been very positive as was shown by the high number of responses to the Advanced Research Projects Agency (ARPA) request for Dual Use technology proposals in 1993 (2,763 proposals submitted worth over $8 billion in funding requirements). (6) Overall, Dual Use technologies will be a consideration for future military programs.

One certain result of the Dual Use initiative is that the DOD may no longer be the driver of many new systems. With a smaller force, we will no longer see the DOD buy the weapon systems in the quantities they did in the past. Smaller lot sizes also force us to look at commercially-developed systems to utilize in military aircraft. Based upon this thinking, we, the authors, approached the airlines and the Commercial Aircraft Group at Boeing to determine what their R&M issues are in order to make a correlation between commercial airline requirements and military requirements. We found that their requirements for improvements in the ability to maintain and support their respective fleets are identical to those of an Air Force maintenance officer. Reliability and maintainability is a common ground for cooperation that can and must be explored and exploited for the benefit of the airline industry's competitiveness in a global economy and the Air Force's combat readiness.

In examining this common ground, one can find many R&M issues which require a unified problem-solving effort. The first common problem area is operations and maintenance (O&M) of aging airframes. As described earlier, the airlines, due to lease considerations and general financial solvency, are no longer making mass buys of newer aircraft. The same is true of the Air Force. For the USAF (including the Air Force Reserve and the Air National Guard), about 50% of the aircraft in the fleet are 18 or more years old. (7:42,44) In addition, KC-135s, C-141s, and B-52s (the mainstays of the larger Tanker/Transport/Bomber fleet) are 30 to 40 years old. For the civilian airlines, about 33% of their aircraft fleets are 20 or more years old. (8:24) A visible example of this by the airlines is the operation of the Boeing 727 which has been out of production for about 10 years. These older aircraft understandably experience increased corrosion fatigue and mortality failures. In addition to the structural failures associated with age, both the airlines and the Air Force are seeing components fail in ever-increasing rates. The parts were designed to be "life of the aircraft," but the life has been extended, and the parts fail.

What the maintainer needs is a portable device to detect corrosion and fatigued parts. This device must allow for quicker and more thorough inspections. An improved technology to help with fault detection and isolation of various aircraft subsystems is also needed. If, under the Dual Use concept, the DOD develops these capabilities for their aging fleets, then the transition cost to the civilian airlines would simply be the cost of procuring the system. Other systems which will help reduce cost could first be developed within the DOD and then transferred to the commercial world and vice versa for commercial developed technologies.

A final area to be discussed regarding Dual Use is the cooperation and sharing of total quality experiences. Some airlines have implemented Total Quality or Quality Management procedures as part of their daily operations. Southwest Airlines for one, allows its employees to assist with the increased use of assets in their daily operation. United Airlines is also going this way by allowing the union to buy into the company which will give the employees more say in the company's operation. The employees will have more of a stake in the company than just a job. This empowerment results in reliability and maintainability improvements which impact the daily operations and profit margin.

The government can work with the airlines to share lessons learned from both sides thereby making each operation more efficient. This sharing of data will also reduce the number of mistakes experienced by both sides.

Reliability

In order to develop more relialeb systems, we must first understand which components will cause us problems and which will require periodic maintenance and inspection. The DOD, especially the USAF, has set up a database for reporting and tracking this data. Several of the airlines also do this, but each uses a different database. These various tracking systems cause problems as they do not allow for easy compilation and analysis of information by the manufacturers and their subvendors. The aerospace industry needs a standard maintenance reporting system for the tracking of failure data. This was a major topic discussed at the Boeing R&M Conference in June 1993, however, no standard methodology was identified for this system. (4) According to an article in *Aviation Week and Space Technology*, Boeing has developed a computer software tool which can identify the components on aircraft which are causing the most costs. By identifying these, the airlines can then make recommendations to Boeing and their suppliers as to which parts need to be improved. It also allows the airlines to change their maintenance procedures to improve efficiency. (9)

Another method for improving the reliability of an aircraft is for the design engineer to take a two-step approach in developing a system integrity program. First, in order to make a system more reliable, the designer needs to understand the environments in which this system will be operated and maintained. The engineer also needs to understand the chemical and mechanical characteristics of materials used in the manufacture of this system. In doing this, several questions should be asked to identify and analyze these different parameters. Once these parameters are identified, they may then be added to the aircraft specifications. Some of the questions the design engineer should ask are: How is the item to be packaged and transported from the point of manufacture and all subsequent stops in the pipeline (depot/central maintenance facility, operating location, and flight line) until the item is placed on the aircraft? Under what conditions will the aircraft be operating? What is the level of quality of the manufacturing process? Will residue from this process result in corrosion? The answers to these questions will ensure an aircraft can be designed to meet the real operating environment. If the design engineer uncovers a problem, he/she can then look at ways of improving the design, such as using more robust materials or parts. If improvements to the design are not practical, the next solution would be to develop periodic inspection/preventative maintenance procedures to catch a degraded component before it causes a catastrophic failure. These tasks lead to understanding how the system will be operated prior to design completion.

Second, the design needs to be analyzed in an environmental stress screening program to identify the unique or hidden failure points. The engineer needs to define how the system functions and identify when and why it does not function correctly or it fails. The designer needs to ask questions like: What are the critical components, and what type of combined stresses will build up to cause this unit to fail? Will the components have a graceful degradation to failure or will they fail "hard" causing a complete system shutdown? All these factors need to be defined in this stress screening to evaluate how the design will perform in the real environment. Analysis of the system is basic engineering. Turning this analysis into a time parameter for failure occurrence is a challenge. Finite element analysis programs may be required.

Another aspect of reliability is how a system changes over time. When discussing reliability with practitioners, one often hears that reliability is like a bathtub, with its curves. Using this analogy, our main area of concern is the part of the reliability curve for a system (aircraft) known as mortality. This part of the curve sees many frequent and sometimes catastrophic failures in otherwise reliable systems and aircraft. Aircraft skins, like the body of a car, can only take so many pressurization cycles and hours in the elements. Cracks and fatigue necessitate many hours of maintenance to isolate and repair. Internal cracks, corrosion, and fatigue can lead to incidents like the Aloha Airlines 737 in Hawaii where the skin broke away in flight. (8) Electronic components are also often characterized by their susceptibility to mortality failure. They normally tend to fail after long use due to corrosion and fatigue.

One option to reduce the impact of mortality failures is to place sensors in different systems or sections of the aircraft. This type of imbedded sensor technology is being developed by the Air Force under the Smart Structures/Smart Skins program. This would allow for the continual measurement of loads placed on a system/component, enhancing the capability to predict fatigue on the system. This type of technological breakthrough would permit future aircraft to tell us when to repair a structure or remove a component before that item becomes critical. Another option is to design the system to allow modifications which will extend the life of the component. Overall, we need to understand the problem first so we can make changes to provide the most reliable part possible.

Maintainability

The airlines are currently showing concern over the competitive advantage that maintenance and maintainability can provide a company. According to an article in *Aviation Week and Space Technology*, the US airlines spend $9.0 billion, roughly 11% of their operating expenses, on maintaining their fleets. (10) By making this process more efficient, they can realize a great cost savings which will allow them to reduce ticket prices. American Airlines and a few others have offered partnerships to smaller airlines to retain their maintenance capability, even on aircraft they no longer fly. This "teaming" will permit them to amortize the large start-up costs over more aircraft, thus making it affordable to expand in the future. It also allows the maintenance operation to generate a profit center for the carrier. American is also running television commercials showing how important maintenance of aircraft is to the airline; "Even the most junior mechanic can keep an airplane in the hanger if something isn't right."

The maintenance setup for the civilian airlines varies with the carrier. Some have a three-level maintenance operation, (flight line, intermediate, and a depot/overhaul source), some a two-level, (flight line and depot/overhaul source), and others contract out depending on the capital cost and the number of aircraft being operated by that carrier. With this in mind, we believe several areas need to be addressed in the maintainability arena.

With the older fleets, both in the DOD and the commercial airlines, we see a great need for a methodology to easily detect corrosion. When these aircraft were built, they were designed for a certain life cycle—not for the extended service imposed on them. As we increase the number of flying hours on an aircraft, its true measure of age, we increase the chance of having corrosion, structural fatigue, and system mortality. One area for teamwork would be to develop and field a system which could detect and identify faults before they become critical and make the aircraft unsafe.

The Materials Directorate of Wright Laboratory is currently developing new non-destructive evaluation/inspection (NDE/I) techniques to address the cracking and fatigue problems associated with the DOD's aging aircraft fleet. As the research is proven out, these NDE/I techniques should become very valuable to both the DOD and the commercial airlines. It will permit the user to reduce the maintenance/support costs and make these aircraft a more valuable asset for the airlines and the DOD. If the inspection process is accurate, then the available maintenance man-hours are correctly assigned to the problem, and the aircraft is returned to service in a expeditious fashion.

Another area to consider under maintainability is troubleshooting the various systems within the allowed time on the ramp. For the airlines, this is usually only about one hour at the gate prior to its next flight. A handheld or portable device is needed which could model and diagnose all the different systems to identify which component has failed. Since most of the older aircraft have mechanical-type systems, a model-based automated technical order diagnostic aid is recommended. This tool would allow the maintainer to enter a fault code, and the output would identify the possible candidate or candidates for the subject fault. This would reduce the cannot duplicate (CND) rate which for some airlines is as high as 75% and 30% to 40% for the military. (4) A reduction in the CND rate reduces the time required to turn an aircraft. It has also been estimated that these false removals cost about the same as an actual failure when the component under investigation is removed and replaced. Reducing this would be a big cost saver.

A model-based diagnostics system was developed and successfully tested within the Flight Control Division of Wright Laboratory for the flight control system on the F-16 aircraft. The system allowed maintainers, whether they were a novice or an expert, to find the failed component. Currently this fault detection/isolation system is being expanded for all systems on the F-16 aircraft. (11) A commercial derivative of this technology is planned for the Boeing 777 "On-Board Maintenance System." Boeing is planning to develop this system to assist the airlines with a more cost-effective and time-sensitive device to avoid expensive gate delays and flight cancellations. (12) This technology may be expanded to produce affordable retrofits to older commercial and military aircraft. Every CND eliminated through proper diagnostics correlates directly to the ability to generate revenue.

Identifying faults and corrosion on the flight line in a more expeditious manner will also result in a large cost savings. This can be done as a cooperative effort between the airlines and the DOD in the development of maintenance aids. The aerospace industry as a whole has only to gain in this area, with both sides obtaining the necessary tools to maintain their fleets in a more efficient manner. This will help the airlines to become more soluble and generate more revenue, which will in turn allow them to expand and upgrade their fleets. The DOD will be able to downsize without compromising combat capability. The bottom line is: Improvements in maintainability will reduce costs.

Summary

The commercial airlines are streamlining now in reaction to the changing economy. This is a natural result of a cycle which sees expansion during strong economic times and reduction during stagnation or recession. The DOD is following this same path as reduced budgets result in a reduced force structure. However, instead of seeing this as a problem, we should look at this as an opportunity to work together under the Dual Use philosophy to develop better systems for both government and industry.

As a result of this streamlining process, the airlines as well as the DOD have been operating their fleets longer than anticipated by the manufacturer. This results in many problems with reliability and maintainability of these older systems. One way we can cooperate is by formulating a standard database for fault reporting in order to define problem components. This will allow the supplier of these items to provide a more reliable and better product. Once these problems have been identified, they can be corrected. In addition, the supplier can work on improving the design through analysis of the operating and maintenance environments. These cooperative efforts will also lead to the development of maintenance aids which will enhance a support operation. Reducing the maintenance time and the CND rates will allow airlines to better schedule their aircraft making their operations more efficient and profitable. This is a great competitive advantage as a lower operating and support cost can translate into a lower ticket price.

In relation to the airlines and the DOD working together, the best chance for a small airline will be a teaming arrangement with one or more of the major carriers. These smaller airlines can cover the low capacity routes allowing the major carriers to concentrate on the major domestic and international routes. The key to success for this teaming will be in reducing operating costs. Only through the sharing of maintenance and reliability data can the costs of maintenance, including actual maintenance labor cost and lost revenue associated with maintenance, be substantially reduced. The common ground of reliability and maintainability of aircraft will provide a platform upon which America can put its best and brightest minds to work. This teaming will result in a more reliable, sustainable, and profitable commercial airline industry, and a more reliable, sustainable, and combat ready Air Force.

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The Air Force Oil Analysis Program

Captain Calvin L. Guyer, USAF

Introduction

The Air Force Oil Analysis Program (OAP) was established to accomplish four objectives:

(1) Improve the use of Air Force equipment by efficiently and cost effectively using oil analysis.
(2) Collect and analyze technical data and improve oil analysis effectiveness in diagnosing potential equipment failures and oil breakdown.
(3) Ensure that all Air Force OAP plans and operations are integrated with those in the Joint OAP (JOAP).
(4) Use the most cost effective means of monitoring the condition of used oil and oil-lubricated mechanical systems by using oil analysis.

OAP is one part of a condition-based maintenance philosophy that relies on the detection, measurement, and trending of wear metals to determine mechanical wear of equipment and predict impending failure before serious malfunction or secondary damage occurs. Another aspect of oil analysis is the determination of lubricant physical properties. The Air Force program, however, does not include physical property testing (PPT) of lubricants. PPT could include viscosity, contamination (water, glycol, fuel), additive content, flash point, particulate level, etc. An effective OAP provides for the collection of wear metal data and correlating that data with physical findings during engine teardown and overhaul. Correlating these data results in improved diagnostic abilities for future impending failure detection.

Oil analysis is a tool beneficial to both maintenance and engineering. Maintenance benefits from a successful program because of the ability to predict impending failure and correct the problem before catastrophic failures occur, thus increasing engine availability. Engineering benefits because wear metal trending provides a diagnostic tool for analyzing failure modes and developing risk mitigation schedules, either through decreased inspection intervals or component design changes.

Maintenance Philosophies

Three basic maintenance philosophies are part of a comprehensive maintenance program. They are: corrective maintenance, preventive maintenance, and condition-based maintenance. Jet engine maintenance includes aspects of all three philosophies.

Corrective maintenance, or "*fix it when it breaks*," allows for failures of equipment when that failure isn't critical. Replacing a light bulb when it burns out is corrective maintenance. This approach is unacceptable when a failure could cause secondary effects leading to loss of life or equipment. In some cases, the unanticipated loss of equipment availability may cause unacceptable impacts to the mission.

Preventive maintenance anticipates the end of useful life of a component, based on a statistical analysis, and maintenance is scheduled for its replacement *before* a failure occurs. To continue with the light bulb example; when 30% to 50% of bulbs either burn out or fail to produce sufficient light, it is usually more cost effective to initiate a blanket changeout of all bulbs. Savings in manpower alone is dramatic. Preventive maintenance, although useful in some circumstances, can be costly. Parts removed from service are scrapped or reworked and may still have useful life remaining.

Condition-based maintenance uses equipment health indicators to anticipate failures *before* they occur. This requires a focused approach to analysis, planning, implementation, and feedback. Condition-based maintenance requires a higher level of sophistication (monitoring devices, sensors, probes, data reduction, analysis techniques, etc.) than preventive or corrective maintenance, however, overall operating costs are generally reduced.

The Oil Analysis Process

Figure 1 shows the process at a macro level. The process begins with the crew chief (or designated person) drawing an oil sample at the appropriate time interval. Various intervals are specified for the different engine/aircraft combinations. DD Form 2026, Request for Oil Analysis, is then completed and forwarded to the nondestructive inspection (NDI) laboratory for spectrometric wear metal analysis. Most bases have organic OAP capability. The operational mission of a particular base may not warrant a local laboratory. In those instances the crew chief will pull an oil sample, complete the DD Form 2026, and send the sample to another laboratory for analysis. This laboratory could be operated by the Army, Navy, or Air Force. The analysis and report of results are provided free of charge based on an interservice agreement between the Army, Navy, and Air Force.

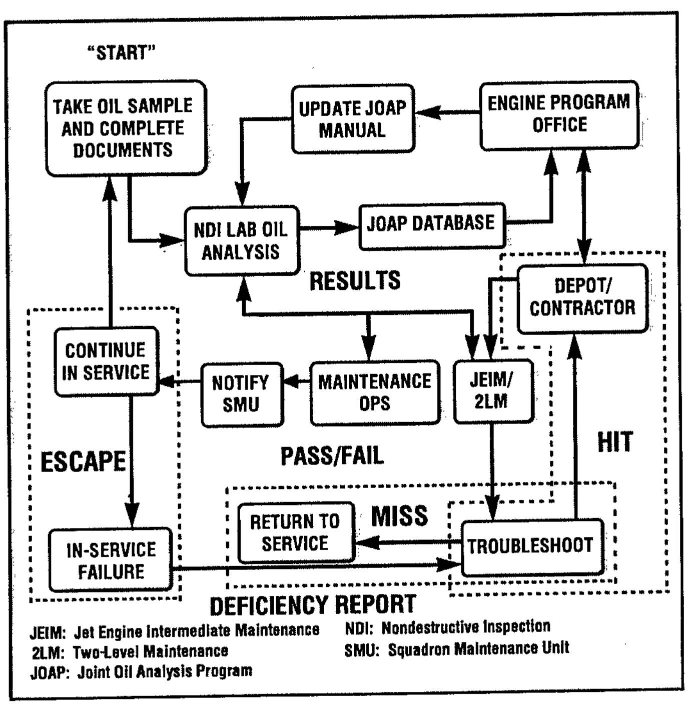

Figure 1. The Oil Analysis Process.

Various techniques are used to record and analyze the results. The NDI technician may use automated analysis software such as Comprehensive Engine Management System (CEMS) IV or the Air Education and Training Command (AETC) analysis program. The end goal of each software routine is to automate the technical guidance contained in TO 33-1-37-1/-1/-3/-4, *Joint Oil Analysis Program Manual*. Some labs are not automated and perform the data analysis manually.

The information generated by the wear metal analysis is stored locally (either manually or via a computerized database) and relayed to a maintenance control group. Typically, the Air Force waits to generate another sortie on an engine undergoing wear metal analysis until after the NDI technician approves the oil sample as being within an acceptable range. The exact guidance for each aircraft or engine varies.

If the oil checks out as acceptable, then maintenance can release the engine for additional operational commitments. If, however, the NDI technician suspects a problem, such as abnormal wear or oil contamination, another oil sample may be directed. The NDI technician can recommend grounding of an engine if sufficient evidence exists.

Engine grounding results in troubleshooting. If a causal factor is identified (referred to as a "hit") then the equipment is repaired and returned for operational use. The repair process varies by engine family. If no causal factor is identified (referred to as a "miss") then the engine is returned to operational use. An "escape" is an engine which resulted in an oil-wetted component failure without being coded properly when sufficient evidence existed, or which failed without any trending or magnetic chip detector signs.

The current information management system is intended to capture hit and miss data, however, that data often times does not get recorded or entered into the database. The process of updating the OAP history for a particular engine is convoluted and subject to error. The maintenance finding must be fed back to the NDI laboratory. If this does not occur properly, then the failure data is forever separated from the diagnostic data.

The JOAP history and failure data must be reviewed on a continuous basis to ensure that limits and diagnostic criteria are correct. It is intended that the JOAP database provide hits, misses, frequency distributions, causal factors, etc. This data, and data reported from the field through other systems, are forwarded to the engine program offices for review. It is incumbent upon the engineer in the engine program office to establish both limits and diagnostic criteria based on the correlation of failure data with the OAP indication. The JOAP manual is then updated and the process continues.

Spectrometrics

Oil samples are analyzed for wear metal content using a technique referred to as atomic emission (AE) spectrometrics. Many of us were first introduced to the basic concept of spectrometrics in a high school chemistry class. A small sample of some element, say copper for example, was placed on the end of wire. The sample was then "burned" in the flame of a Bunsen burner. The copper emitted a greenish color. Similarly, other elements, when burned, gave off other colors. The spectrum of light emitted during this process is unique for each and every element. Through this crude method, the student could identify the element(s) present in a given sample.

This rudimentary technique, however, is limited to only a few sample elements and only works well if the sample to be burned is relatively homogeneous. A spectrometer is a very delicate piece of optical equipment specifically designed to separate light into its component wavelengths. Figure 2 is a schematic of the spectrometers in field use today.

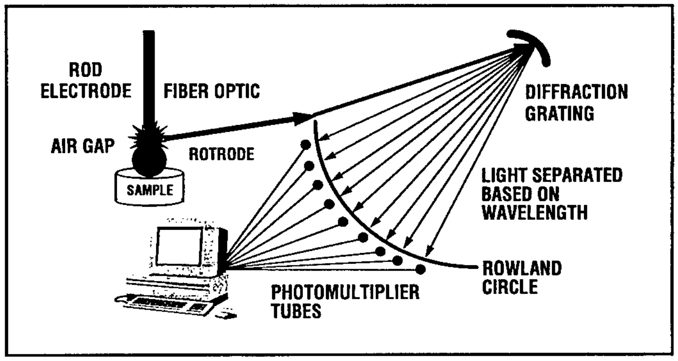

Figure 2. Atomic Emission Spectrometrics.

The "disk" electrode, or rotrode as it is sometimes called, is bathed in a sample of the used engine oil. The rotrode rotates picking up oil and suspended metallic particles and brings them into the air gap. An electric potential is applied to the rod electrode (the rotrode is grounded) and the resulting arc in the gap vaporizes the oil and wear metal sample. The electrons in the vaporized elements absorb energy and are forced into higher, unstable orbits. The electrons cannot remain in this state. The electrons release energy in the form of light and return to their lower, more stable orbits. The resulting light is focused onto a diffraction grating. The defraction grating separates the light into various wavelengths. The light is received by special light sensitive sensors and sent to an internal computer for analysis. At the end of the analysis interval (about 30 seconds) the part per million (ppm) count for various wear metals is provided to the technician.

This technique has its limitations. First, and foremost, the current implementation of AE spectrometrics is only effective for wear metal particles in the 3-7 micron size. Particles 7-10 microns in size are only partially vaporized. It is very unlikely that particles above 10 microns will be vaporized and thus will not be included in the analysis results. The reason is that sufficient energy does not exist in the gap to vaporize the larger wear particles. The gap energy is limited because of the potential for an oil fire. Particles below 3 microns are too small to produce a sufficient amount of detectable light. The result, as shown in Figure 3, is a "blind spot."

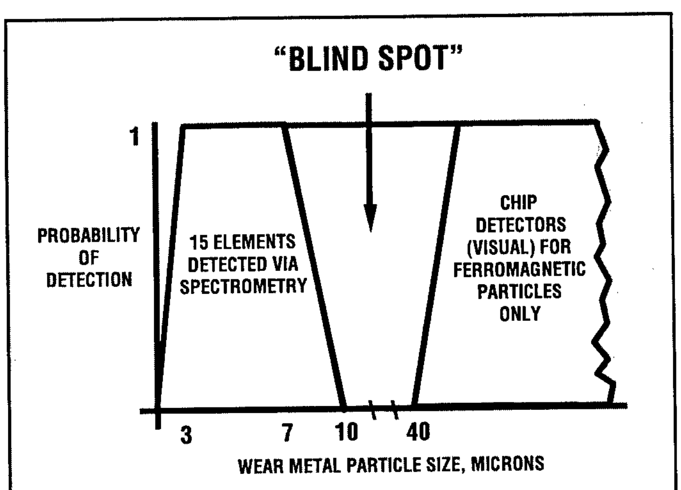

FIgure 3. Atomic Emission Spectrometric Blind Spot.

The next available opportunity to detect wear particles in the oil is via a magnetic chip detector (MCD). However, not all engines are equipped with a MCD. This visual method is good for magnetic (and only magnetic) particles above 40 microns.

It is assumed that these two diagnostic techniques are capable of detecting abnormal wear and thus impending failure. The failure mode, therefore, must present itself as 3-7 micron wear particles or 40+ micron ferromagnetic particles, and the diagnostic criteria must be properly followed. Failure modes not falling into these regimes, failure to comply with established limits and diagnostic criteria, or ineffective limits and diagnostic criteria will allow a potential failure mode to go undetected by the current oil monitoring techniques. Additional techniques should be pursued if it is determined, through testing or field feedback, that a particular failure mode will not be detected by either AE spectrometrics or MCD.

OAP depends on the long-term trending of wear metals as well as monitoring the short-term increases from sample to sample. Figure 4 and Figure 5 show actual long-term wear metal trend and a 10-hour trend data from a J60-T-25 (T-37B) engine. The 10-hour trend is calculated using the following formula:

$$\frac{A - B}{C - D} \times 10 = \text{equivalent 10-hour trend}$$

A = ppm this sample
B = ppm last sample
C = operating hours this sample
D = operating hours last sample

The data point at 28 hours could be due to an error in the an analysis. It could also be due to significant oil consumption (to be discussed later), not an unusual situation on this engine. The right end of Figure 4 shows the wear concentration is in the abnormal range (12+) and has been operating in the high range (10-11) for the previous three flights. The 10-hour trend on the last sample is 5 ppm/hr (parts per million per hour). The established limit is 3 ppm/hr. No other wear metals exhibited a remarkable trend. TO 33-1-37-3 states that a copper only trend indicates main bearing cage or accessory case section wear. This particular engine was pulled for maintenance and a notation indicated that a starter adapter housing was removed and replaced. This data presents a well defined picture of how oil analysis is used. The trend was well established, the maintenance call was made, and the problem corrected. This is not always the case.

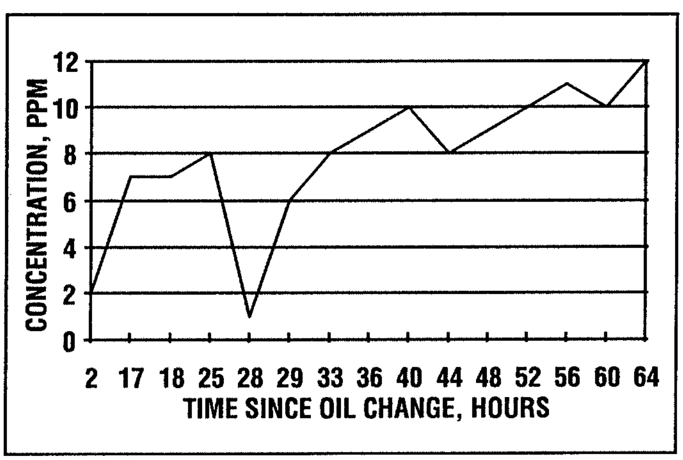

Figure 4. Copper Wear Metal Trend.

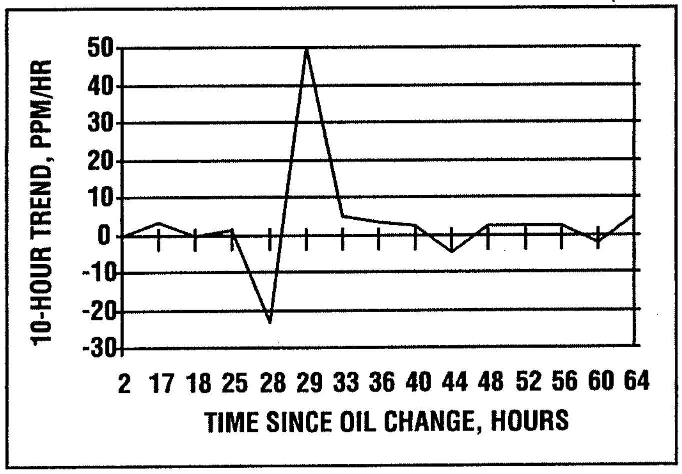

Figure 5. 10-Hour Copper Wear Metal Trend.

Two recent F100-PW-220 engines had no wear metal trend. All monitored elements reported 0 ppm. However, maintenance detected chips on the MCD. The database contains no maintenance finding. This case shows that it is not valid to assume that microscopic wear particles (3-7 microns) will accompany visible chips (40+ microns).

Various maintenance actions affect OAP analysis. First is oil consumption and servicing. Oil consumption results in either the loss of wear particles or the concentration of wear particles. Figure 6 illustrates how the addition of virgin oil to an engine has the unwanted effect of wear particle dilution.

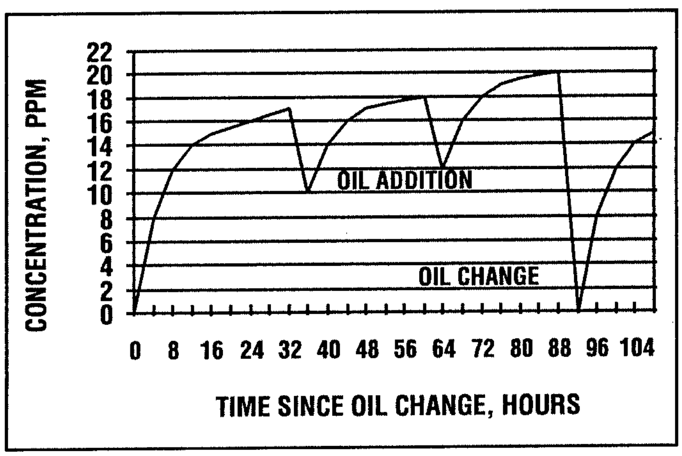

Figure 6. Effect of Oil Addition and Oil Change.

The effects of dilution are relatively benign as long as the oil additions do not become a significant portion of the oil capacity of the engine. However, for a high oil consumption engine or an engine regularly consuming at or above its limit in oil, the effects of dilution can be dramatic. For instance, an engine with a 5-gallon oil tank which consumes an average of 0.5 pints of oil per hour of operation will have 54% of its original oil left after 50 hours of operation, and only 28% left after 100 hours. This assumes that the engine is "topped off" after each hour of operation.

Currently, no guidance exists to assist the laboratory technician in correcting for abnormal consumption. TO 33-1-37-2 simply states that the oil consumption rate trend provides additional information to aid the laboratory evaluator and maintenance personnel in evaluating equipment condition. Oil additions can and should be used as another indication of engine health. Most engine technical orders (TOs) specify an oil consumption limit based on engine operating time. Oil consumption must be consistently documented, trended, and used in the engine health decision making process. An increase in consumption followed by a flattening or downward trend of the wear metal concentration may be cause for increased monitoring.

A partner to oil consumption is oil changes. An oil change removes most, if not all, of the wear metal particles from the engine. All trending is lost. In general, the Air Force engine management philosophy does not require periodic oil changes. However, engine maintenance and troubleshooting actions may require an oil change. Frequent oil changes will mask abnormal wear because wear metal concentrations take time to build-up in the oil. Again, no guidance exists to assist the laboratory technician to correct for oil changes. Engines close to or at the abnormal 10-hour trend limit or which show elevated (although normal) wear metal concentrations after a recent oil change may be cause for increased monitoring.

Failure Reporting

Feedback of maintenance findings and failure data in this process is imperative. Feedback provides both the engineer and technician a basis for improved diagnostics and troubleshooting guidance. AFR 66-39, *Oil Analysis Program*, identifies as an Air Force OAP objective to collect and analyze technical data and improve oil analysis effectiveness in diagnosing potential equipment failures and oil breakdown; and collect historic engineering data for use in each phase of the weapon system's life. Air Force policy is that data feedback on the accuracy of the OAP laboratory-recommended maintenance actions will be used to judge the effectiveness of OAP. Engine program offices are responsible for distributing teardown results on all engines and components sent to the depot as a result of an OAP laboratory recommendation. The key here is that the engine or component must be identified as detected by OAP.

TO 00-35D-54, *USAF Deficiency Reporting and Investigating System*, allows for the submission of Category II deficiency reports (DR). A Category II DR can be used for tracking deficiencies by agreement of the single manager and the using command DR point of contact. Failure of bearings, gearboxes, and other oil-wetted engine components pose a hazard to personnel and the weapon system and, therefore, warrant tracking.

TO 00-35D-54, Table 3-3, requires that, on oil-wetted component failures, the last five OAP readings be included in block 22b. For some engines (like the J85 for example) five samples represent about 100 flight hours. This may be sufficient data to draw a trend. However, on the F100 engine, installed in the F-16, five samples represents about 10 flight hours. Sufficient analysis data must be supplied to allow for a trend to be established. As discussed earlier, oil changes and additions can play a significant role in correlating OAP data with failure data. This data can be included as a note in block 22 of the DR. OAP laboratories can supply a copy of DD Form 2027, Oil Analysis Record. This form provides information regarding hours since overhaul, hours since oil change, wear metal analysis data, and laboratory maintenance recommendations.

Oil servicing data is contained in either AFTO Form 781H, Aerospace Vehicle Flight Status and Maintenance Document, or AFTO Form 781J, Aerospace Vehicle-Engine Flight Document. TO 00-20-5, *Aircraft, Drone, Aircrew Training Devices, Ending and Air Launched Missile Inspections Flight Reports and Supporting Maintenance Documents*, requires the use of AFTO Form 781H. The AFTO Form 781H may not be available for the crew chief to document oil servicing. The pilot takes this form to debrief. Many field units are overprinting the AFTO Form 781J, which does not go to debrief, to document oil servicing. This is an effective field response to an ineffective TO procedure. An update to TO 00-20-5 will include guidance on the use of AFTO Form 781J to document oil servicing.

Conclusion

The effective management of this program requires the participation of both field and depot activities. Catastrophic failures increase the cost of engine ownership and decrease the availability of an operational asset. Constant vigilance of wear metal trends (and other engine health indicators) is required to implement an effective on-condition maintenance philosophy. Modifications to procedures, limits, and diagnostic criteria may be necessary.

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CURRENT RESEARCH

Air Force Logistics Management Agency FY95 Program

Below are our in-work top projects for FY95. If you are interested in any of these projects, please contact the project officer. If commercial lines are used, dial Area Code (334) 416-plus the last four digits of the DSN number.

Contracting

Environmental Contracting Reference Guide, LC943372

Objectives: SAF/AQC has sponsored this effort to develop an environmental contracting guide for contracting specialists that: (1) provides an overview of environmental regulations and regulators, (2) introduces environmental issues and concepts that impact contracting mission accomplishment, (3) provides a source for identifying further guidance, (4) explains terminology used in the environmental field, and (5) provides an overview of the contracting processes that support environmental projects submitted by organizations on base.

Capt John Perry, AFLMA/LGC, DSN 596-4085

Local Procurement Test Program, Phase II, LC943430

Objective: The AFLMA will collect and analyze purchase data from the 23 test locations on a quarterly basis. We will provide quarterly reports to HQ USAF/LGS to show program usage, and provide evaluation of price differences between depot and local purchase items. The final report will provide an analysis to determine: (1) if the local purchase test program provides a cheaper and more responsive means of buying specific required assets, (2) if additional policies or procedures need to be modified to allow greater flexibility to wing commanders, and (3) what impact the Local Purchase Test Program may have on other programs such as War Readiness Reserves and Standard Base Supply Stock Levels.

SMSgt George Dupin, AFLMA/LGC, DSN 596-4085

Contingency Contracting Deliberate Planning Handbook, LC943271

Objective: Develop a guide to help operational contracting squadrons prepare for contingency deployments. This handbook will provide guidance for base-level contracting officers when evaluating operations plans and preparing for contingency deployments.

Capt Tom Snyder, AFLMA/LGC, DSN 596-4085

Logistics Plans

Support Agreements Management System (SAMS) V3.1, LX9404900

Objective: Correct problems in SAMS V3.0 that have been identified by users in the field to include: (1) addition of edit and copy capabilities to block 7, (2) fix the backup and restore files capability, (3) provide the capability to put "indefinite" in block 4, and (4) update the User's Guide.

Ms Kathleen Wilkison, AFLMA/LGX, DSN 596-3535

Air Field Information System (AFIS), LX931022

Objective: Develop a procedure with applicable software allowing MAJCOMs to update AFIS. AFIS currently feeds the APORTS file used in the Joint Operation and Planning Execution System (JOPES). Currently there are no means for the MAJCOMs to update AFIS even though many site surveys have been recently accomplished. The procedures and software will provide direct input to the defense Mapping Agency Center who maintains AFIS.

Lt Col Ronald Butts, AFLMA/LGX, DSN 596-3535

Collocated Operating Base (COB) Assessment Program, LX933531

Objectives: (1) Implement corrections to problems discovered in the beta test installed during December 1993 at the 51st Collocated Operating Base Support Squadron (COBSS) Republic of Korea. (2) Once corrected, the COBSS Assessment Program will automate the task of gathering vital information of over 300 functional areas.

Capt Joe Fleming, AFLMA/LGX, DSN 596-3535

Automated Mobility Processing System (AMPS), Part II, LX9413710

Objective: AMPS I development produced a prototype application to manage every aspect of squadron-level deployment management. AMPS II continues development and refinement of AMPS software for eventual Air Force-wide implementation. Functionality to be added includes: (1) local area and wide area network (LAN/WAN) capability, (2) a supply system interface to allow for local printing of deployed custody receipts and electronic reporting of deployed equipment status, (3) printing of hazardous shipment forms, (4) cargo and personnel shortfall reporting, (5) personnel immunization and training tracking, and (6) Status of Resources and Training Systems (SORTS) input processing.

Capt Jay Jennings, AFLMA/LGX, DSN 596-3535

Maintenance and Munitions

AMC Maintenance Commitment Threshold, LM9404800

Objective: Provide Air Mobility Command (AMC) with a formal method for determining the Maintenance Commitment Threshold for each Mission Design Series (MDS) (C-5, C-141, KC-10, KC-135). This formal method will aid AMC and its bases in protecting the integrity of scheduled maintenance programs.

Capt Mark Gray, AFLMA/LGM, DSN 596-4581

Logistics Handbook for Aircraft Maintenance Managers, LM930352

Objective: Provide a guide for maintenance managers at the squadron officer and senior NCO level and for both flight line and backshop users. The guide will incorporate changes over the past several years that affect flight line and backshop maintenance organizations.

Capt Michael Labosky, AFLMA/LGM, DSN 596-4581

Munitions Manager's Reference Guide, LM9324520

Objective: Update the *Combat Munitions Officer Reference Guide* into the *Munitions Manager's Reference Guide*. The guide will incorporate field-level changes since the first edition and will include detailed Munitions Accountable Systems Officer (MASO) information to be used in the absence of formal in-residence training.

Capt Carey Tucker, AFLMA/LGM, DSN 596-4581

CAS Training Evaluation, LM9406040

Objectives: (1) Evaluate Combat Ammunition System (CAS) training programs at Sheppard Technical Training Center and implementation training provided by SSC/LGW and MAJCOMs during unit conversions to the AT&T 3B2 computer system. (2) Evaluate the effectiveness of unit and command follow-on training programs. (3) Provide recommendations on how to improve CAS training at all levels.

CMSgt Alan Richardson, AFLMA/LGM, DSN 596-4581

Quality Assurance Tracking and Trend Analysis System (QANTTAS) Version 3.0, LM930601

Objective: Revise the current QANTTAS (version 2.2) software program to reflect the changes identified by the MAJCOMs (HQ ACC, HQ USAFE, HQ PACAF, HQ AFRES, and NGB) to meet the needs of base-level quality assurance programs.

Capt Dee Jay Jackson, AFLMA/LGM, DSN 596-4581

Reduction of Precision Measurement Equipment Laboratory (PMEL) Infrastructure, LM9416800

Objective: Identify areas to streamline, reduce costs, and increase the efficiency of PMEL operations.

Capt Lois Schloz, AFLMA/LGM, DSN 596-4581

Feasibility Study of Active Noise Reduction Headsets, LM9415300

Objectives: (1) Search for a low-cost, effective alternative active noise reduction (ANR) headset that will meet the needs of ground crews. (2) If such alternatives are not found, evaluate the possibility of developing and procuring ANR headsets for maintenance personnel.

Capt Edward Stalker, AFLMA/LGM, DSN 596-4581

Alternative Aircraft Deicing Technologies, LM9416500

Objective: Review existing "off-the-shelf" technologies that will reduce groundwater and watershed contamination from aircraft deicing operations. This study will look at three distinct phases of the deicing process: (1) aircraft deicing, (2) fluid run-off, and (3) "end of pipe" recycling.

MSgt Stanley Mynczywor, AFLMA/LGM, DSN 596-4581

Comparative Analysis of TF33-7A Unit and Depot Intermediate Maintenance: Repair Costs and Manpower Utilization vs Authorization Under Two-and Three-Level Maintenance Concepts, LM9530500

Objective: Review TF33-7A engine maintenance costs and manpower utilization at unit and depot intermediate level to give Air Staff visibility of MAJCOM expenditures and manning.

Lt Col Hugh Campbell, AFLMA/LGM, DSN 596-4581

Supply

Regionalization of Adjusted Level Stocks, LS9412500

Objectives: (1) Examine current inventory levels and demand patterns for items assigned adjusted levels at selected bases. (2) Describe the population of assets assigned adjusted levels. (3) Investigate the utility of regionalized stockage for selected items. (4) Recommend an implementation methodology for regionalizations, if feasible.

Capt James Johnson, AFLMA/LGS, DSN 596-4165

An Alternative to the Combat Supply Management System (CSMS), LS9415800

Objectives: (1) Develop alternative methods of feeding Standard Base Supply System (SBSS) stock levels to Weapon System Management Information System/Sustainability Assessment Model (WSMIS/SAM) that increases data accuracy and timeliness while reducing costs associated with maintaining the data. The system should provide MAJCOM, Air Logistic Center, and Air Staff users the ability to access the system, download reports and audits, and query historical data. (2) Provide recommended alternatives and evaluation results to HQ USAF/LGSS.

CMSgt Jack Coley, AFLMA/LGS, DSN 596-4165

Computation of Primary Operating Stock (POS) Offset for In-Place Readiness Spares Packages (IRSP), LS9421700

Objectives: (1) Determine possible alternative methods for calculating the POS Offset. (2) Compare the results with current methodologies. (3) Recommend a standardized POS Offset calculation based on the most accurate methodology.

Capt Marcus Hogins, AFLMA/LGS, DSN 596-4165

C-5/C-141 Supportability Analysis, LS9421710

Objectives: (1) Analyze spares support for the C-5 and C-141 fleet. (2) Recommend changes if necessary. We will consider distribution of assets, management review codes, "bit and piece" support, repair capabilities at the wholesale level (manpower, funding issues, etc.), and production negotiations.

Capt Marcus Hogins, AFLMA/LGS, DSN 596-4165

Analysis of Redistribution Order (RDO) Process, LS9434910

Objectives: (1) Investigate reasons why automated RDOs (item manager and system-directed) are not being honored and status is not being provided. (2) Recommend improvements to the current process.

SMSgt Richard Alford, AFLMA/LGS, DSN 596-4165

Aggregate Inventory Model for Expendables, LS9434920

Objectives: (1) Develop an aggregate inventory model for SBSS implementation. (2) Investigate alternative implementation schemes for an aggregate model concept which require a minimum of inventory augmentation money. (3) Describe specific SBSS implementation guidance.

Capt Steven Reynolds, AFLMA/LGS, DSN 596-4165

Analysis of Air Force Shipment Losses, LS9328920

Objectives: (1) Quantify the volume and value of shipment losses for the Air Force and identify any adverse trends. (2) Quantify the value added of the M-16 program (The Shipment Loss Analysis Report), and recommend changes to the procedures as necessary.

SMSgt Richard Alford, AFLMA/LGS, DSN 596-4165

Lean Logistics AWP Assessment, LS9422200

Objectives: (1) Analyze past usage rates for assets consumed by the repair shop, and determine if projected bench stocks are adequate. (2) Determine if past shop consumption data is accurately reflected in wholesale inventory system (D035K Stock Control and Distribution System), and predict whether or not bit and piece support will be a problem under a Lean Logistics repair concept.

Capt David Jones, AFLMA/LGS, DSN 596-4165

Transportation

Replace the -2 Plus Computer Program, LT932181

Objective: Develop an easy-to-use, comprehensive microcomputer program to fill out the Shipper's Declaration for Dangerous Goods form. This form will replace the DD Form 1387-2, Special Handling Data/Certification, when the new AFJMAN 24-204, *Preparing Hazardous Materials for Military Air Shipment,* is released.

Capt Jim Toler, AFLMA/LGT, DSN 596-4464

Transportation Manager Handbook, LT932291

Objective: Update the *Transportation Officer's Handbook* (in new format) to reflect changes in Air Force policy and base-level organizational structure which have taken place since the book was last updated in 1988.

Capt Eric Williams, AFLMA/LGT, DSN 596-4464

Processing Advance Transportation Control and Movement Documents (ATCMDs) for Vendor Shipments, LT940340

Objective: Evaluate methods for improving vendor shipments to overseas locations requiring ATCMDs.

Maj Douglas Tazoi, AFLMA/LGT, DSN 596-4464

Transportation Lean Logistics Initiatives, LT940880

Objectives: (1) Baseline Two-Level Maintenance (2LM) movement requirements and costs. (2) Baseline airlift investment item movement requirements and costs. (3) Determine mission capable (MICAP) movement requirements and costs.

Capt Eric Williams, AFLMA/LGT, DSN 596-4464

Advanced Traceability and Control for Air Force (ATAC-AF) Data Evaluation, LT943490

Objective: Establish a confidence level in the completeness of raw data feeding into ATAC-AF by subsystems.

Maj Douglas Tazoi, AFLMA/LGT, DSN 596-4464

Supervisors—Professional or Phoney?

In spite of unprecedented breakthroughs in science and technology, it's surprising that many people still haven't mastered the art of managing people.

We continue to face the dilemma of dealing with two basic types of contrasting overseers—professionals and phonies.

As long as phonies continue unchecked, our bid for excellence is greatly limited. Let's take a look at some differences between the phonies and professionals.

A phoney becomes bogged down by tradition. "I've used this method for 20 years, so it should still work," they assert with complacency. A professional welcomes innovation and believes methods can be changed to suit the times.

Professional supervisors encourage their people to seek improvement. Phonies, although they won't admit it, feel threatened when any of the workers further their education.

A phoney seldom gives positive recognition. "Medals won't buy you a cup of coffee," they say. A professional looks for opportunities to give credit to those who deserve it.

Professionals earns the workers' respect through understanding and fairness. Phonies demands respect through intimidation.

A phoney resents all criticism and easily blows his or her top under pressure. The professional supervisor keeps an open mind to criticism and stays level-headed under trying conditions.

Professional supervisors are people oriented—they have a genuine concern for their workers. Phonies pay lip service to the workers' welfare—they are too self-centered to care about anyone but themselves.

In a nutshell, a phoney is an overbearing eccentric who uses fear, force, or position to get results at the expense of the people. Conversely, a professional strikes a balance between the workers' needs and the unit's goals—having a positive influence on morale and the mission.

Technical Sergeant Mario Casuga
Administration Chief, Command Section
US Military Training Mission
Riyadh, Saudi Arabia

Airframe and Powerplant Certification: A "Plus" for Maintenance Personnel and the Air Force

Captain Edward Kramer, USAF

The military has many career fields that have a corresponding civilian certification enabling easy access and transfer to the commercial sector. Pilots, navigators, legal, medical, and air traffic controller personnel are only a few of the military career fields that achieve formal recognition for their training and qualifications by their civilian counterparts. Aircraft maintenance is certainly a critical career field deserving similiar recognition.

One of the most important civilian aircraft maintenance training documents is the Federal Aviation Agency (FAA) approved Airframe and Powerplant (A&P) license. The Air Force recognizes that A&P certification significantly strengthens the career-specific education and skills of our maintenance personnel. Actions which help Air Force maintenance personnel acquire A&P certification benefit maintainers individually and the Air Force as an institution. In that vein, the Air Force recently completed a formal evaluation and recognition of over 347 of our aircraft maintenance technical courses and curriculum with the FAA. As a result, HQ USAF/LGMM, the Community College of the Air Force (CCAF), and the FAA published *Guidelines for Evaluating USAF Maintenance Training*. This document recognizes certain portions of USAF aircraft maintenance technical courses as fulfilling part of the FAA's formal school training requirement, and was distributed to all FAA certified aviation maintenance schools in the US. This publication is an important first step in recognizing military aircraft maintenance training; nevertheless, more work can be done to facilitate our enlisted force's access to formal FAA A&P certification. Our enlisted mechanics can gain certification on their own; however, it is a long and arduous process, not greatly facilitated by any USAF program.

Advanced education is never easy to quantify in terms of "payback." Individuals who have obtained A&P certification, however, have proven that they take their careers seriously and have expanded their knowledge beyond the barriers in their career field to cover all aspects of aircraft maintenance. An A&P certification expands the technicians' awareness of many aspects of aircraft maintenance.

As a professional in the logistics career field affecting over 78,000 maintenance personnel, one should be aware of the basic requirements of obtaining A&P certification. There are two methods available to obtain the FAA A&P license: (1) with experience (FAR Part 65), and (2) formal schooling (FAR Part 147). Written, oral, and practical exams are required for the General, Airframe, and Powerplant sections (Figure 1).

Federal Aviation Regulation (FAR)	Requirements
PART 65 (Experience)	30 Months Experience (18 months experience to obtain either an Airframe or Powerplant certification) Evaluation - oral, written, and practical
PART 147 (Maintenance Schools)	1,900 Hours (Minimum) (oral, written, and practical exams following school) General - 400 Hours Airframe - 750 Hours Powerplant - 750 Hours 50% Classroom 50% Hands-On

Figure 1. Federal Aviation Agency Airframe & Powerplant Certification Requirements.

Federal Aviation Regulation Part 65 (Experience):

Individuals with aviation maintenance experience may apply for authorization to be tested upon presenting documented evidence, satisfactory to the FAA of one of the following:

(1) At least 18 months of practical experience performing the duties appropriate to the rating sought (airframe or powerplant).

(2) At least 30 months of practical experience concurrently performing the duties appropriate to both the airframe and powerplant rating.

The documented evidence can be in the form of letters from past and present employers, supervisors, military service records, business records, etc. The FAA inspector must be able to determine that the type and amount of experience meets the Part 65 requirements for eligibilty to test. After eligibility has been confirmed, the FAA inspector will issue authorization for each area to be tested; General, Airframe, and Powerplant.

For those applicants not wanting to challenge the written tests, many aviation maintenance schools offer courses for the experienced, yet unlicensed mechanics. Emphasis in these schools is on theoretical discussion necessary for successful completion of the written exams. The courses are designed to expand the knowledge of competent mechanics, not to create aviation mechanics.

Federal Aviation Regulation Part 147 (Maintenance Schools):

Part 147 specifies Aviation Maintenance Technician School (AMTS) requirements for A&P certification. An AMTS is an FAA certified educational facility authorized to train personnel for careers in the aviation industry. A minimum of 1,900 hours are required for Part 147 A&P certification. The recently completed *Guidelines for Evaluating USAF Maintenance Training* standardizes advanced placement for AMTS evaluation under Part 147. Each AMTS sets its own policies for granting credit. The amount of credit granted will depend on the military courses taken and the curriculum structure of the AMTS.

Captain Kramer is presently a Project Manager, Maintenance and Munitions Division, Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama.

Ensuring Software Supportability During Acquisition: An Air Force Case Study

Captain Anthony C. Johndro, USAF
Daniel V. Ferens

Introduction

Active consideration of software support during acquisition or development is tantamount to successful software support. A key objective of the Air Force Materiel Command's new Integrated Weapon System Management (IWSM) philosophy is to ensure software supportability by making the same organization responsible for both software development and software support. This paper presents a set of guidelines for ensuring supportability of software for IWSM systems. Although these guidelines were written specifically for IWSM, they will help all software managers more effectively consider software support during acquisition.

Current State of Software Support

In 1992, United States companies spent over $30 billion supporting or maintaining software. This represents 60% to 80% of each company's software budget. It is estimated that this percentage will grow to 90% by 1995. Some companies must increase their support staffs by 15% each year just to keep up with the growing demands for changes. (10:70) The situation is no better for the Department of Defense (DOD). Figure 1 shows the past and predicted future DOD expenses for embedded (weapon system) software. (5:4-4) If 70% of these costs are for software support, DOD spent about $21.7 billion for software support in 1993.

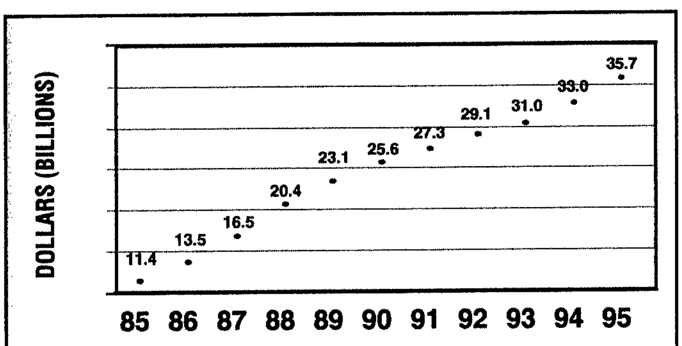

Figure 1. DOD Weapon System Software Expenses.

One reason that software support costs are high is that software support is sometimes misunderstood. Some managers wrongly equate software support to mere "maintenance" or correcting software errors. However, error correction only accounts for about 17% of software support costs. (8) Most software support activities may be categorized as either "adaptive" support which involves responding to changing data or processing requirements, or "perfective" support which involves enhancements to improve features such as performance, reliability and maintainability, or efficiency. Software maintainability (or better, supportability) is a characteristic of software which reflects the degree of effort required to perform the following tasks: correction of errors, addition of features, deletion of capabilities, and adaptation or modification. (11:50) Also, support procedures can be quite elaborate, and reiterate developmental activities (Figure 2). (9) Perhaps a good synonym for software support is "redevelopment." (7:16-2)

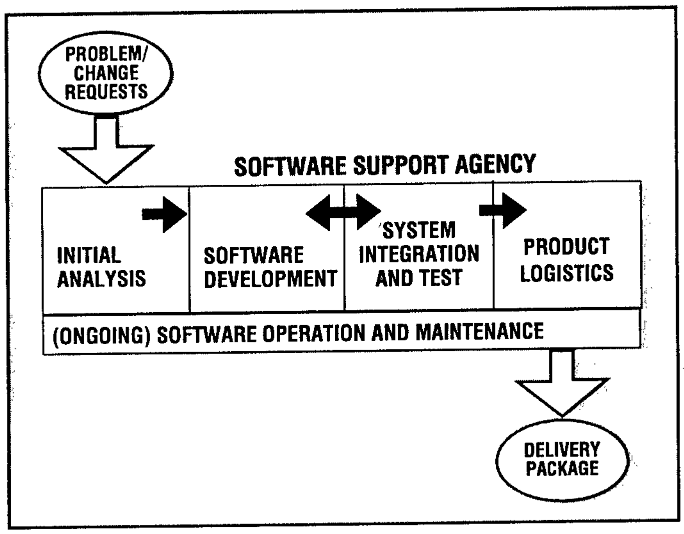

Figure 2. Software Support Process.

Perhaps the major cause of the high cost of software support, however, is that support usually has not been considered adequately during development. (7:18-2) Software developers are concerned with building new products, while supporters or maintainers, are concerned with keeping software programs functional and current until they are no longer used. If the support organization is separate from the development organization, the supporters have probably had little interaction with the developers. Consequently, the software developer is often more concerned with meeting contractual obligations for delivering a completed software product than with providing supportable software. (2:24,27) Software supporters, however, need a product which can be easily modified.

The IWSM Process

Until recently, the Air Force's organization exacerbated the problems discussed above. Software development was the responsibility of a System Program Office (SPO) assigned to Air Force Systems Command (AFSC), while post-deployment software support (PDSS) was usually the responsibility of an Air Force Logistics Command (AFLC) organization. Unless the AFLC organization worked closely with the AFSC SPO and could influence them to address PDSS, software support concerns were not sufficiently addressed during development.

However, after AFSC and AFLC were combined into a single Air Force Materiel Command (AFMC), the IWSM philosophy was implemented. (1) IWSM is:

> . . . the AFMC management philosophy for acquiring, evolving, and sustaining products. It empowers a single manager with authority over the widest range of decisions and resources to satisfy customer requirements throughout the life cycle of a product. (1:2)

This single manager, the System Program Director (SPD), is assigned to oversee a program during its entire life cycle. The SPD manages two groups, the Development System Manager (DSM) organization during development, and the Support System Manager (SSM) organization during PDSS. The DSM and SSM organizations, in turn, manage elements of their systems through Integrated Product Teams (IPTs). The IPTs are multidisciplinary teams responsible for developing or supporting their assigned system elements. The ultimate goal of IWSM is to provide a better product to the customer.

Under IWSM, the SPD now has an inherent interest in PDSS issues since he or she is now responsible for software support as well as software development. Because up to 80% of the software effort, time, and budget are spent in PDSS, the SPD is motivated to pay particular attention to techniques which improve software supportability. (6:82) Planning for PDSS is now a vital activity for the SPD during development.

The IWSM PDSS Study

The objective of this study, conducted as an AFIT thesis effort, was to determine how SSM organizations should plan for software supportability and involve software support personnel during development to improve software supportability for weapon systems and Command, Control, Computer, Communication, and Intelligence (C4I) systems developed under IWSM. (3) To help meet this objective, a questionnaire was sent to 15 of the 21 weapon system and C4I programs designated as IWSM pilot programs. The pilot programs were in two categories: operational systems and systems still under development. The questionnaire was divided into five parts:

(1) IWSM program management structure.
(2) PDSS planning efforts.
(3) How PDSS plans are (or were) implemented during software development.
(4) Transition from software development to PDSS.
(5) Operational software support.

Of the 15 programs surveyed, 8 programs responded. These programs included seven weapon system programs and one C4I program. The seven weapon system programs included two space programs, two electronic programs, and three aircraft programs. Also, of the eight programs responding, four were operational and four were still under development. The results of the five-part questionnaire are now discussed.

Program Organizations Under IWSM

Figure 3 shows that, of the 40 IPTs identified by the eight responding programs, 29 (or 72%) have software as part of their IPT efforts. The 11 IPTs which don't have software involvement are in support areas such as site activation, contracting, and system testing. Therefore, most IPTs directly managing acquisition or PDSS for weapon and C4I systems can be expected to manage software.

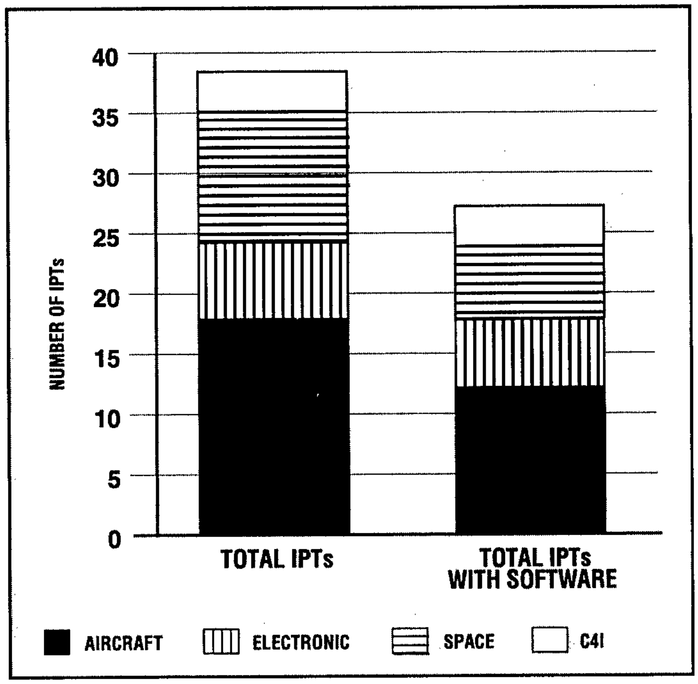

Figure 3. Integrated Product Teams with Software Effort.

Another noteworthy aspect of IWSM programs is the degree of coordination among IPTs. A coordinated team effort can result in better planning and conflict resolution for resources, budgets, schedules, and requirements. The coordinated team approach also facilitates necessary ongoing communication among the various IPTs. Figure 4 shows that five of the eight responding programs currently employ a coordinated management approach. Of the three programs that do not currently use a coordinated approach, one manager believed that, under IWSM, more coordination will take place in the future. It is also interesting to note that six of the eight responding programs include both development and PDSS personnel in their Computer Resource Working Group (CRWG). The CRWG is established early in a program to insure PDSS issues are addressed during the entire life cycle of a program.

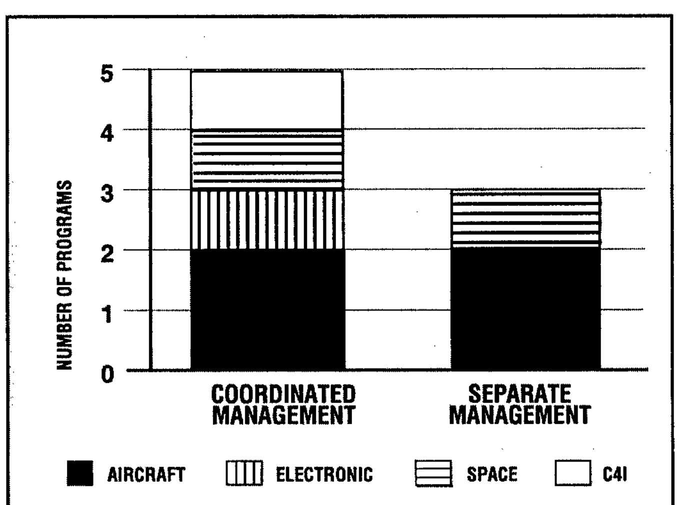

Figure 4. Degree of Managerial Coordination.

Planning for PDSS

All but one of the eight programs surveyed has a Computer Resources Life Cycle Management Plan (CRLCMP) to address PDSS planning. The CRLCMP, normally prepared by the CRWG, addresses PDSS planning, including such items as number and type of personnel, equipment, and environment required for PDSS. The other program used a system maintenance plan for PDSS, such as an Integrated Logistics Support Plan. Three programs had both a system plan and a CRLCMP, but most software information was confined to the CRLCMP. The system maintenance plans usually were sparse in software information.

Including software product assurance personnel in PDSS planning, such as those specializing in software configuration management (SCM) and software quality assurance (SQA), can be highly beneficial. According to Dean, the bottom line purpose of SCM is to ensure continuing logistics supportability of systems, and similar statements can be made for SQA. (4:48) Figure 5 shows that seven of the eight responding programs use SCM personnel in PDSS planning, and three programs used SQA personnel. Only one program did not use software product assurance personnel in PDSS planning.

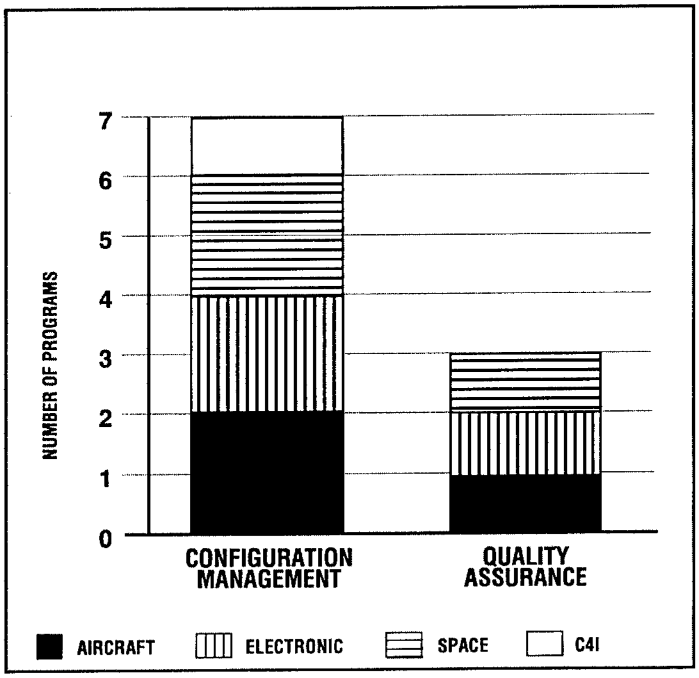

Figure 5. SCM and SQA Personnel Involvement in PDSS.

Implementing PDSS Planning During Development

Aggressive participation by SSM software support personnel in contract monitoring activities, such as reviews and testing, can promote software supportability. Personnel can not only better assess contractor progress in the area of supportability, but can also learn more about the software they will later support. In six of the eight programs surveyed, SSM personnel participated in formal reviews and audits. SSM personnel in five programs were also able to perform code inspections, but did not often perform these inspections rigorously.

Figure 6 shows the level of participation in software testing by SSM personnel for the eight programs surveyed. In six of the eight programs, SSM personnel witnessed at least some of the tests performed by the contractor, and SSM personnel performed some hands-on testing in four of the programs. In two of the programs, SSM personnel actually performed supportability testing.

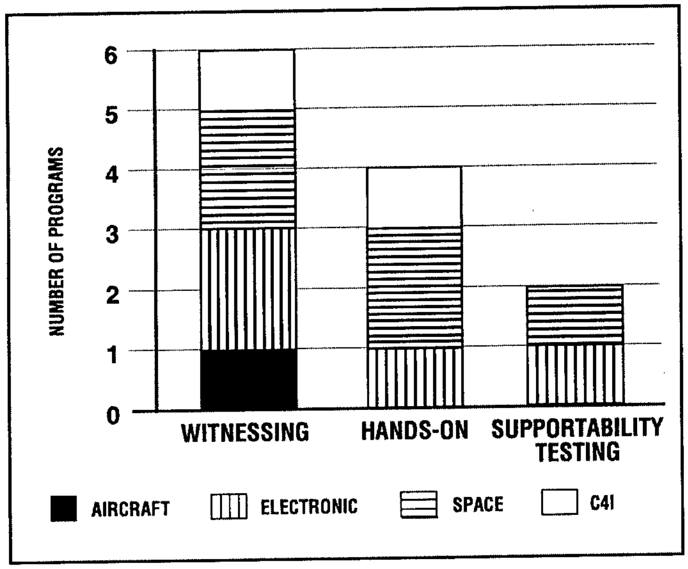

Figure 6. Levels of Testing Participation.

Transitioning from Software Development to PDSS

The information here applies only to the four programs surveyed which are currently in PDSS. One of the programs was divided into two separate programs, which represent different configurations of a system where PDSS plans differed. Figure 7 shows that, of the (now) five programs surveyed, three reported a routine, or easy transition, while the other two reported that transition was relatively difficult. Personnel in all three programs for which transition was routine received training, while training was not received for one of the two difficult programs. This may indicate that training can facilitate transitioning from development to support. However, it must also be noted that the three routine programs are entirely supported by the developing contractor, while both difficult programs have mixed government and contractor support. Furthermore, one of the difficult program's SPD is managing several dozen development and PDSS efforts concurrently, which complicates any transition.

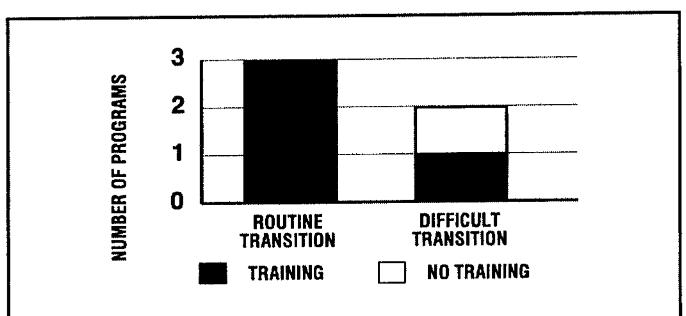

Figure 7. Transition Training Versus Transition Ease.

Operational Software Support

Figure 8 shows that, for the five programs shown in Figure 7 above, three programs experienced routine PDSS, while the other two experienced relatively difficult PDSS. Not surprisingly, the three programs for which PDSS is routine are the same three programs for which transition was routine. Again the ease of PDSS may be correlated with training, but is also likely to be due to total contractor support. A computer

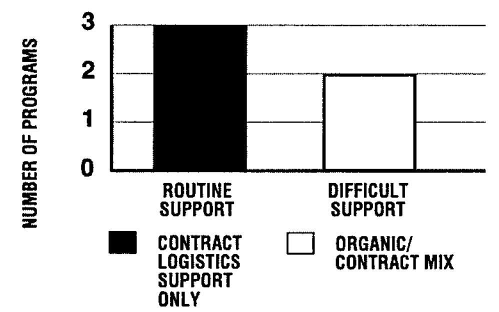

Figure 8. Routine Versus Difficult Software Support.

resources manager for one of the difficult programs wrote an operating instruction in an attempt to minimize transition and PDSS difficulty for future programs. While the effects of this operating instruction are unknown at this time, it appears to be a step in the right direction.

Manager's Recommendations

The questionnaire also asked the managers to make recommendations for improving software supportability for current and future programs. The following are their recommendations:

(1) Try to retain common software configurations among systems.
(2) Require the software developer to use modular code.
(3) Use standard software libraries to minimize recoding of common algorithms.
(4) Institute common coding practices between the development and support organizations.
(5) Ensure the required software documentation is deliverable under a development contract, including the documentation produced by subcontractors.
(6) Educate contractors as to why the items above are needed by the government.

Study Conclusions

It is difficult to generalize results from a sample of only eight programs, and it is even more difficult to generalize results of only one C4I program to other C4I programs. Nevertheless, certain results of the study can provide useful guidance for weapon system, C4I, and other programs managed both within and outside the government. First, involvement by PDSS personnel throughout the development process is necessary for software supportability. PDSS personnel especially need to be involved in the planning process, where poorly-written CRLCMPs have been correlated with difficulty in PDSS. PDSS personnel should also actively participate in reviews and audits and in testing. Active participation by product assurance personnel such as those involved in SCM and SQA can also enhance supportability. Adequate documentation is necessary for supportability and, although this was not proven by the survey results, adequate training is also needed. Finally, coordinated management among IPTs or other program personnel can also enhance supportability.

As part of the study effort, a draft set of supportability guidelines for IWSM programs was prepared. The complete guidelines are documented in the thesis. (3:Appendix B) The table of contents from these guidelines, shown in Table 1, highlights areas of concern for considering software supportability during development.

1. OVERVIEW
   - 1.1 Software Supportability Background
   - 1.2 Integrated Weapon System Management (IWSM) Background
   - 1.3 Purpose
   - 1.4 Overview
2. PLANNING FOR PDSS
   - 2.1 Introduction
   - 2.2 Planning for PDSS
     - 2.2.1 Management and Administration
     - 2.2.2 Software Engineering and Test
     - 2.2.3 Software Configuration Management
     - 2.2.4 Software Generation and Distribution
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Summary

Because of the high cost of software and shrinking budgets, the Air Force and most other agencies must focus on improving supportability of the software they develop or acquire. The Air Force has taken a major step toward improving supportability with the IWSM concept. However, IWSM must be implemented properly to achieve the desired objectives. The results of the 1993 AFIT thesis study demonstrated ways in which supportability can, and should, be considered during development in IWSM and other programs.

Implementing these guidelines can greatly contribute to the benefits of supportable software.

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Today's Advanced Database Technology Can Lead to Cost Effective Logistics Systems Development and Maintenance

Paul J. Breaux

The appropriate application of advanced database technology can reduce the cost of computer-based logistic systems development and maintenance by more than two-thirds. A major thrust in providing effective and efficient integrated logistics support is the ability to obtain, maintain, and provide real-time access to vital data. The cost of developing and maintaining automated logistic systems is consistently increasing. This technology also addresses the objectives of Continuous Acquisition and Life-cycle Support (CALS) requirements regarding the establishment of less paper-intensive operational logistic environments. This paper addresses the benefits and limitations of using today's advance database technology to develop automated logistic systems.

Introduction

The backbone of an effective and efficient integrated logistic support (ILS) effort is the management of vital data. The cost of developing and maintaining computer software to support logistics initiatives is becoming prohibitive. It is estimated that 40% to 80% of information systems' costs are directly attributed to maintenance. (1) Additionally, it is estimated that 60% to 70% of the Department of Defense (DOD) software dollars are spent annually on software maintenance. (2) Everyone can agree that the cost of logistic systems' development and maintenance can adversely affect what programs are implemented or changed and when changes should be accomplished.

The premise of this paper is that the use of currently available database technology, especially database management systems (DBMSs) with Fourth-Generation Language (4GL) support features, will not only keep ILS systems' maintenance cost down, but will reduce the cost of developing applications as well. To support this premise, this paper is broken down into four sections following a definition of a 4GL:

(1) Objectives of 4GLs.
(2) Benefits gained by using 4GLs.
(3) Limitations that should be considered when selecting and using 4GLs.
(4) Three examples of how advanced database technology has been applied successfully in meeting diverse logistic requirements.

Throughout the remainder of this paper the term "4GL" refers to DBMS 4GL.

What Is a 4GL?

A 4GL is an automated/semi-automated programming language usually tied to most major DBMS applications that is easy to learn and simple to use by non-programming individuals. Specifically, 4GLs give users a somewhat less complex method of setting screen displays, establishing canned queries, generating reports, and are usually tied to a data storage interface methodology. Most 4GLs support microcomputer and minicomputer systems application development, however, there are 4GLs for mainframe systems as well.

Most DBMS applications such as Oracle by Oracle Corporation, dBase IV by Borland, FoxBase+ by Santa Cruz, Focus by Information Builders, Access by Microsoft Corporation, and Paradox by Borland provide internal or utility type 4GL capabilities. Third-party support is also available. Clipper by Nantucket, Action Plus by Information Management, Pathfinder by Data Systems, and CLIPnet by DataSync Technologies are just a few examples of third-party 4GLs available to support dBase IV DBMS application development and maintenance efforts.

Objectives of 4GLs

4GLs are designed to meet two specific objectives:

(1) Assist non-programmers in generating software applications without learning more complex conventional high-level programming languages.
(2) Assist in increasing the productivity of the normal programming process.

Benefits

The benefits of using a 4GL are:

- 4GLs assist non-programmers in software development.
- 4GLs assist programmers in being more productive.
- 4GLs provide a simpler method of developing screen displays and report formats.
- 4GL software vendors provide end-user support.
- The use of 4GLs frees programming staff for more complex application development.
- 4GLs reduce time/expense of application maintenance.
- 4GLs prevent or limit poorly structured applications.
- 4GLs usually support automatic error trapping.
- 4GLs usually are self-documenting.
- 4GLs usually support on-line help features.

Due to the ease of use of most 4GLs, end users are able to develop their own applications and make appropriate enhancements, especially to screen displays and report formats. Many 4GLs simply require the user to select a field from a database table and point to a specific location on a screen to position the field for data entry, query, update, and/or reporting. The application developer is usually allowed to modify the display size of the field, make the field mandatory, provide on-line help features, specify field color, attach the field to a default or customized look-up table, make the field invisible to the user, use pop-up/pull-down windowing to support data management, and/or allow line drawing to build borders around field(s) or the full screen display. Many 4GLs support cut and paste utilities to minimize application development time. These are only a few of the options available to application developers when working with 4GLs. Most important, this type of user support allows the programming staff to use valuable and expensive application development time for more complex applications.

The use of 4GLs can reduce the traditionally lengthy software modification cycle. The design of most 4GLs allows users to find the area needing change, and, with minimal keystrokes, make the change in an expeditious manner. Well-designed 4GLs normally allow 80% of routine changes to be made in one hour, whereas, it may take months using conventional methods of programming. (3:237-253) Also, since most applications developed using 4GLs are easy to understand, different people, from those who initially programmed the application, are able to make changes to existing code within a short period of time and with minimal frustration.

Most 4GLs are designed to prevent or limit the construction of poorly structured programs which could cause problems after the application is implemented. A good 4GL will walk the user through the sequence of operations in a clear, concise, structured manner, and generate English-like source code into transparent object code. The user does not have to worry about learning structured programming constructs to get the job done.

Some 4GLs provide automatic and/or selectable error trapping. It is nearly impossible to identify and provide error trapping on every possible type of error that may occur within a program using conventional program methodology. However, many 4GLs provide automatic error trapping or allow the user to identify specific error conditions and/or provide error messages to be tailored to individual user needs.

Many 4GLs are self-documenting. For example, some 4GLs insert comments into existing source code as the application is being generated. This means that users do not have to take time away from normal programming duties to document software that is being developed or modified. Additionally, the documentation can be used for future modifications of existing applications.

Most 4GLs support on-line help features. This feature usually provides the application developer with either a default help display screen or command line display facility, and/or allows the developer to customize the help facility to support specific end-user requirements. This feature is invaluable in meeting diverse end-user assistance criteria.

Many 4GLs are tied to self-generating data dictionaries which allow them to make full use of existing databases. Because databases are becoming very common in the workplace, the time expended on user training is kept to a minimum. Well-designed 4GLs are linked to a DBMS allowing users to design and build screen displays and generate responses that increase the efficiency and effectiveness of most organizations.

Limitations

Although the use of 4GLs allows users to develop applications faster and provide more cost-efficient maintenance, there are some limitations. The following limitations should be considered when purchasing and/or using 4GLs:

- Some applications are too complex for 4GLs.
- Response time is usually slow.
- 4GL-developed applications usually require extensive internal/external storage.
- Some 4GLs do not provide enough general support for routine applications.

Some applications are too complex for 4GLs. Even with a high-level programming language interface, some applications should not be attempted using 4GLs. 4GLs are best used with simple, routine applications required for reporting specific information (usually tied to stored data). If appropriate, however, a user should consider a 4GL which can be interfaced through a high-level programming language such as C, FORTRAN, or Ada. This interface capability will assist application developers in addressing specific application limitations.

Depending on the design of the DBMS architecture (relational versus hierarchical), response time may be slow. Because 4GLs are designed to make the job of creating and maintaining applications easier, it carries some overhead. This overhead is additional code that is generated each time an application is developed or modified. The additional code may address such areas as display screen management; on-line help functions; DBMS interface drivers; data management utilities; operating system support features; error trapping; data input, update, modification, and query triggers; device drivers; report structures; etc. This additional code is generated whether it is used by the application or not. This overhead usually slows response time regarding database queries, graphic presentations, and report generation. Responsiveness should be considered when selecting a 4GL for use in application development.

In addition, overhead with 4GLs will have a direct affect on the amount of internal and external storage space used by applications. 4GL applications tend to take up approximately one-half to twice as much storage space as required for conventional applications. If there is limited internal memory (Random Access Memory) or available storage on a disk drive, care must be taken when selecting and using 4GLs.

Some 4GLs do not provide enough general support to meet most routine application requirements. There exist 4GLs that are designed to meet specific functional requirements such as graphics, report generation, spreadsheet interfaces, query operations, or application generation only. Based on user requirements, the 4GL selected should be a combination of these functions with a seamless (if possible) interface between complementary functions.

Finally, the use of 4GLs can breed complacency regarding data administration. Some users believe that because some 4GLs provide well-structured application software, there is no need to model or efficiently design data structures that are required for use with the 4GL. Poorly designed data structures could adversely affect the performance of the 4GL. Care must be taken with database design in order to get the most from a 4GL.

Examples of Actual 4GL ILS Applications

> ILS is basically a management function that provides the initial planning, funding and controls which help to assure that the ultimate consumer (or user) will receive a system that will not only meet performance requirements, but one that can be expeditiously and economically supported throughout its programmed life cycle. (4:11)

An important function of ILS is providing real-time configuration management support throughout a system's or product's life cycle. Using advanced database technology to automate this function also addresses CALS digital data requirements. Under CALS standards and specifications, data stored using database technology should be in the following digital formats: Integrated Graphics Exchange Specification (IGES) (MIL-D-28000), Standard Generalized Markup Language (SGML) (MIL-M-28001), Raster Graphics (MIL-R-28002), and Computer Graphics Metafile (CGM) (MIL-D-28003). The storage, retrieval, and maintenance of CALS-formatted digital data is supported by most major DBMS and 4GL vendors.

The first example of the application of 4GLs is the development of a Configuration Management System (CMS) by the author. This system was developed to meet ILS configuration management requirements in accordance with MIL-STD-483 and 480. In addition, this system supports reviews and audits in accordance with DOD-STD-1521, DOD-STD-2167A, and software quality assurance requirements addressed in DOD-STD-2168. Figure 1 provides the main menu display for this system to illustrate the options available to the user.

WELCOME TO THE
AVIONICS AND SUPPORT SYSTEMS DEPARTMENT
CONFIGURATION MANAGEMENT SYSTEM

1 CONFIGURATION ITEM ENTRY/QUERY/UPDATE
2 CONFIGURATION CONTROL/TRACKING
3 QUALITY ASSURANCE CONTROL/TRACKING
4 PROBLEM REPORTING (PR) SYSTEM
5 SYSTEM CHANGE REQUEST (SCR) SYSTEM
6 VERSION RELEASE CONTROL/TRACKING
7 PROJECT EQUIPMENT CONTROL/TRACKING
8 DRAWING CONTROL/TRACKING
9 ACTION ITEM CONTROL/TRACKING
10 INDEPENDENT VERIFICATION & VALIDATION
11 EXIT

SELECTION_

Figure 1. Configuration Management System Main Menu Display.

The CMS was developed using SQL*Forms, SQL*ReportWriter, and SQL*Plus from the Oracle Corporation on an IBM-compatible personal computer (PC). The complete system was developed in *five days* including all displays/reports and the software user's manual. It was developed to be flexible in meeting diverse project requirements, however, can be modified with minimal effort to support specific project specifications. The system is used to support appropriate projects requiring extensive configuration management and software quality assurance. An example of the configuration item data entry/query/update screen is provided in Figure 2.

CONFIGURATION ITEM DATA
ENTRY/QUERY/UPDATE SCREEN

PROJECT NUMBER ______
ITEM NUMBER ____________
ITEM NAME ________________________
PERSON/ORG. ____________
ITEM STATUS ____________
TASK DESCRIPTION ________________________
PART NUMBER _____________________
SERIAL NUMBER ___________________
NATIONAL STOCK
NUMBER ________________________
SUSPENSE DATE ____________
VERSION/REVISION ______

CM APPROVAL_ QA APPROVAL_ FCA APPROVAL_ PCA APPROVAL_

Press Page Up To Return To Menu

Figure 2. Configuration Item Data Entry/Query/Update Screen.

This system allows the Southwest Research Institute (SwRI) Avionics and Support Systems Department to track ILS-related configuration item information and to be more competitive in estimating project work. The CMS provides significant cost savings on individual projects for both the SwRI and the project sponsor.

Another example in the use of 4GLs is the Support Equipment Acquisition Management Systems (SEAMS). SEAMS is an automated ILS support system that provides real-time access to the complete inventory of support equipment for the US Air Force. The Air Force Office of Support Equipment Management (AFOSEM) at Wright-Patterson Air Force Base, Ohio, developed SEAMS using SQL*Forms, SQL*Menu, SQL*Plus, and SQL*ReportWriter from the Oracle Corporation. SEAMS provides an automated, on-line, and expanded version of MIL-HDBK-300. This system allows government and contract personnel the capability of accessing the inventory of Air Force support equipment. It includes the capability of identifying specific support equipment through user-entered equipment characteristics. The system was developed using Oracle applications on an IBM-compatible PC and transferred to a VAX minicomputer system after the specific application was developed and tested. With minor exceptions, the transfer process went very smoothly. It is estimated that the use of a 4GL has reduced the cost of systems software development and maintenance by two-thirds.

The third example of how a 4GL was successfully applied deals with the Foreign Military Sales (FMS) organization for proven aircraft at the San Antonio Air Logistics Center. The FMS/Information Management System (IMS) was developed to support ILS planning and control for the F-5 aircraft currently operating in 24 foreign countries. DataPerfect DBMS from the WorkPerfect Corporation was selected because it was inexpensive to purchase and supports organization Local Area Network (LAN)/word processing requirements. The system took *two months* to develop. Personnel were trained to use this system in *two hours*. System maintenance personnel were trained in *one day*. This system's development costs were 13% of a bid made by a major software development vendor, and most maintenance efforts take *less than an hour* to accomplish. Before this ILS system was implemented, management was unable to obtain real-time status information of the ILS process. ILS reporting preparation went from months to hours with the implementation of this automated ILS application.

Conclusion

This paper has provided information on how DBMS 4GLs can decrease software development and maintenance costs and some limitations to consider when selecting or using a DBMS 4GL. This paper proposes that even with some limitations, it is still worth any organization's time and money to look into using DBMSs, specifically 4GLs, for many of their routine software application development initiatives and general data management needs. In the future, the supply of programmers will not be adequate to meet ever-increasing software application development and maintenance requirements. The use of sophisticated database technology will go a long way towards meeting future ILS software application development and maintenance requirements in an environment of diminishing software development resources.

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Candid Voice

Logistics Planning: Changing to Meet the Future?

Major James R. Weeks, Jr., USAF

Looking around today's Air Force you can see that dramatic changes in the world have created a need for change in the Air Force. With the Cold War over, the "new world order" is forcing us to reorient our strategy and approach to handling national security. In this era of shrinking dollars and need for greater efficiency, it appears that rethinking our approach to logistics planning and how to better integrate it into operational planning needs addressing.

One cannot deny the fact that the one aspect critical to effective deployment, as well as sustainment, of combat forces involves logistics planning. In today's world of high tech machinery, advanced computerization, and improving management concepts, the art and science of logistics planning as well as the role of the logistics planner appears to be increasing in importance. Now, due to a diminishing budget, the demand to get maximum utility from our resources is becoming more paramount.

Historically, logistical planning has been the function of a specialized corps of officers, generally taken from other logistics disciplines and trained in planning aspects. In some cases, filling logistics planner (AFSC 66XX, now 025LX) billets has been accomplished by drawing personnel from non-logistics disciplines due to a shortage of available personnel. As a result, commanders sometimes have chosen to rely on operational planners to assess a wing's capability to support a plan or contingency. Based upon these two facts, maybe it's time we streamline current planning capability, both operational and logistical.

One proposal is the combining of the Operations Plans and Logistics Plans functions at wing level making a combined plans office; an initiative I believe has merit and is presently being utilized at several bases.

Additionally, to better serve the needs of the commander, as well as to create a better and well rounded "logistics officer," I believe the elimination of the logistics plans officer AFSC may be in order. In that vein we would then man the Logistics Plans Office by "logisticians" taken from within the wing's "pool" of assigned logistics officers, (supply, transportation, and maintenance). I believe my proposal will work for several reasons:

First, under this initiative the Wing Commander or Logistics Group Commander can selectively man the billets using his knowledge of the needs of the wing as well as performance by his officers to temper his selection and put the best qualified individual in the job.

Second, by making the officer billets a kind of "special duty" position, all officers could be afforded the opportunity to be exposed to the planning environment.

Third, the vast majority of work accomplished in the Logistics Plans Office is done by the enlisted members who would serve as the continuity for the wing's overall effort. Their AFSC would not change. Officer tenure would be determined by the commander based upon needs and performance, and, under a combined plans shop concept, with multiple officers assigned, rotating personnel should not have a negative impact on office performance or capability.

Fourth, by combining Operations Plans and Logistics Plans shops some of the current responsibilities of the Logistics Plans Office could be redistributed to other base functions. For example, the management of War Reserve Materiel (WRM) could be given to Supply; mobility could go to Transportation. This redistribution could possibly reduce overhead and some overall manning requirements.

The problem, as I perceive it, is whether or not we attempt to change our concept of accomplishing logistics planning to meet the new challenges and become more efficient in the process. Currently, the logistics plans career field for officers is one that is not direct accession and obtaining new recruits from other logistics disciplines is becoming increasingly difficult.

Combining planning functions and eliminating the AFSC for logistics plans officers could aid in bettering our overall logistics planning capability as well as creating well-rounded "generalist" logisticians. Someone once said "experience is the best teacher." Let's put our people to the test and expose them to as much "logistics experience" as possible!

Major Weeks is presently the course director for Combat Logistics at the AFIT School of Systems and Logistics, Wright-Patterson AFB, Ohio.

AFIT *The Doorway to Logistics Success*

Student research is a key component of the AFIT School of Logistics and Acquisition Management graduate programs. All students, working either alone or in teams of two, complete a master's thesis. Many of the thesis research efforts are sponsored by agencies throughout the Department of Defense (DOD). This issue highlights the superior thesis research efforts produced by the class which graduated in September 1994. A copy of each thesis is available through the Defense Technical Information Center (DTIC), Cameron Station, Alexandria VA 22304-6145, DSN 284-7633.

AFIT Commandant's Award (Most exceptional research contribution to the student's field)

TITLE: *Evaluation of Air Force and Navy Demand Forecasting Systems*

AUTHOR: Captain Christian J. H. Dussault, Canadian Armed Forces

In March 1993, the Joint Logistics Systems Center (JLSC) selected the Navy's Statistical Demand Forecasting system as the standard DOD forecasting system. The purpose of this study was to evaluate and compare the performance and accuracy of the Navy's Statistical Demand Forecasting (SDF) system, relative to the Air Force Requirements Data Bank (RDB) forecasting system in an Air Force environment. Three different approaches were used to evaluate the performance of each system: (1) an evaluation of each system's reaction to different data patterns using time series components; (2) an evaluation of each system's accuracy using actual Air Force data; and (3) an evaluation of each system's effect on aircraft availability. Contrary to the RDB system, the Navy's SDF system performed well in detecting outliers and trending component data. However, using actual Air Force data, the study found that each system would generate forecasts with approximately the same level of aircraft availability.

Leslie M. Norton Pride in Excellence Award (Outstanding quality) - five 94S recipients

TITLE: *Evaluation of Air Force and Navy Demand Forecasting Systems*

AUTHOR: Captain Christian J. H. Dussault, Canadian Armed Forces (See AFIT Commandant's Award)

TITLE: *Defective Pricing: An Analysis of Factors Affecting Sustention Rates and Disposition Times*

AUTHORS: Captain Tracey D. Kop and Ms. Dawn C. Sutton

Defective pricing occurs when contractors fail to disclose current, accurate, and complete cost or pricing data in their proposals. Failure to submit valid data entitles the government to a refund in the amount of overpayment. With the current backlog of overpayment defective pricing cases and the continuing decline in sustention rates, a better understanding of the factors affecting timely and successful recoupment of defective pricing funds is needed. This research identified factors which significantly affect sustention rates and disposition times and presented models to predict both rates and times. Factors were identified through a literature review and interviews with defective pricing experts. Analysis of variance (ANOVA) was used to determine the statistical significance of the identified factors. ANOVA results indicated the following factors have the strongest impact on both rates and times: alleged defect amount, number of issues, legal complexity, method of disposition, identity of prime contractor, product center, and interest. The models developed explain 73.4% and 48.5% of the variation in sustention rates and disposition times, respectively. Recommendations for improving sustention rates and disposition times based on the research findings are also included.

TITLE: *The Effect of Three-Dimensional Graphs on Decision Making*

AUTHORS: Captains Anita E. Latin and Anthony L. Viallanueva

A randomized order within-subject factorial design with repeated measures experiment was conducted to assess how well DOD decision makers accurately and efficiently performed elementary data collection tasks using various graphs or tables. The factorial experiment analyzed the manipulation of the following three factors or independent variables: (1) mode of presentation, (2) anchoring, and (3) data-set. The effects of these independent variables on the response variables of degree of accuracy and response time (efficiency) were determined. Five treatment levels were selected for mode of presentation, four for task anchoring, and two unique data-set treatment levels for data-set combination. The study found that data extraction accuracy was not significantly affected by presentation format. Overall, the analysis determined there were no elementary data collection tasks in which three-dimensional graphs facilitated more accurate and efficient solutions that two-dimensional graphs and tables.

National Contract Management Association (NCMA) Award (Significant contribution to contract management techniques)

TITLE: *Defective Pricing: An Analysis of Factors Affecting Sustention Rates and Disposition Times*

AUTHORS: Captain Tracey D. Kop and Ms. Dawn C. Sutton (See Leslie M. Norton Pride in Excellence Award)

In addition to the thesis awards, non-thesis awards are also presented:

Society of Logistics Engineers (SOLE) Excellence in Logistics Award (Superior academic record and contributions to the field of logistics)

TITLE: *Logistics Control Facility: A Normative Model for Total Asset Visibility in the Air Force Logistics System*

AUTHOR: Captain Eric C. Lorraine

Computer simulation was used to evaluate the impact of a Logistics Control Facility (LCF) with a Total Asset Visibility (TAV) system on the Air Force logistics system's ability to support a weapon system. For this study the B-1B was chosen as the weapon system of interest. Two performance measures, expected fully mission capable (FMC) rates and expected pipeline quantities, were used to evaluate the simulation results. Two-sample t-tests were used to compare the current logistics configuration of the B-1B with and without an LCF controlling the movement of assets. The expected FMC rate performance measure showed significant results, while the expected pipeline quantity performance measure did not. After determining that the LCF with a TAV system did have an impact on the ability of the Air Force logistics system to support a weapon system, 14 different support configurations were evaluated. Variables included mode of transportation, use of buffer stocks, and use of intermediate repair facilities. Results were analyzed using a randomized block ANOVA and a least significant difference comparison of means. For expected FMC, mode of transportation was the most significant factor. For expected pipeline quantities, the use of intermediate repair facilities was the most significant factor.

The Graduate School of Logistics and Acquisition Management invites suggestions and topics for thesis research in its Master of Science (M.S.) programs. Specific areas covered by these programs include logistics management, acquisition logistics management, supply management, maintenance management, transportation management, systems management, contracting management, cost analysis, software systems management, and information resource management. If you have a thesis topic to suggest, please first contact a faculty member to discuss the topic. Any faculty member may be reached by calling DSN 785-7777, extension 3300, or Commercial (513) 255-7777, extension 3300. Thesis research topic proposals should be submitted to Lt Col Jacob V. Simons, Jr., Assistant Dean for Research and Consulting, AFIT/LA, 2950 P Street, Wright-Patterson AFB OH 45433-7765. For a copy of the *Call for Theses* which details the thesis topic suggestion process, please contact Lt Col Simons at DSN 785-7777, extension 3312.

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USAF Logistics Policy Insight

Career Field Education and Training Plan

The Career Field Education and Training Plan (CFETP) was directed by the Air Force Chief of Staff as a "Year of Training" initiative. Under this initiative, each Air Force career field will develop a career path "road map" to follow for a successful career in the Air Force. This road map will support the objective wing study conducted by Career Field Managers (CFMs), MAJCOM, and wing-level representatives. The CFETP will be a comprehensive document similar in nature to a cradle-to-grave plan for the acquisition of a new weapons system or piece of support equipment.

CFMs are currently writing these plans that will spell out the career path, training and education requirements, promotion requirements, assignment possibilities, and other information that will assist all Air Force members in making career decisions. The information will be comprehensive enough to provide career information to aid both officers and enlisted members in determining which career path or paths to pursue.

Notice I said "path or paths." The CFETP is not so structured as to restrict any individual to only one career path. In fact, personnel may change career paths more than one time during a career. The bottom line is: options will be clearer than in the past.

The CFETP represents a positive change in philosophy. Individuals used to learn of the type of information included in the CFETP by word of mouth or often times, not at all. By the time an individual discovered the career possibilities, his or her career was too far along to either be eligible to perform a specific function or to receive training crucial for an assignment to that function. In either case, not only was the individual affected, but the mission of the Air Force may have been impacted by the nonavailability of trained/qualified personnel. For example, in the past, an Air Force enlisted member, upon completion of an entry-level training course, would arrive at a new duty station and receive an AF Form 623, On The Job Training Record. This form outlined only the 3, 5, and 7-level training requirements. What was hidden from view was the training or educational opportunities available to the individual.

The CFETP brings everything out in the open. It removes the guesswork from career planning and provides a road map for the member's future. Furthermore, one's opportunity to progress equitably in the chosen career field and in an Air Force career is clear. And what is more important, the individual can choose the path. Accession to retirement then means more than merely fulfilling a contract.

Since the CFETP is Air Force specialty specific, individuals should talk to his or her respective supervisor, trainer, or Career Field Manager regarding personal goals and desires. We as supervisors, trainers, and task certifiers must be aware of the importance of the CFETP to the success of a member's career and the impact it will have upon career decisions. Additionally, we need a thorough understanding of all training requirements outlined in the plan. Trainees expect us to assist them in making career decisions based upon our own experiences and knowledge of the career field. We have an obligation to them and to the Air Force to assist them in making the right choices when planning for their future. The CFETP is a tool that provides an "educated" avenue to this planning. The old method was "hit or miss"—some got lucky and broke the code early—some never did! (SMSgt Lou Leonard, AF/LGXX, 227-8648)

Lean Logistics

Lieutenant General Nowak, the Air Force Deputy Chief of Staff for Logistics, describes today's logistics system as too big, unresponsive, and expensive. Lean Logistics is an initiative that promises to overcome these shortcomings. It involves immediate depot repair of failed spare parts; smaller inventories due to consolidation/regionalization of spares; and use of express transportation of spares between the depot and base-level maintenance activities. The shorter pipeline means far less time waiting for parts that are critical to the Air Force's many missions.

In November 1994, the communications-electronics (C-E) community began a demonstration of Lean Logistics involving selected navigational aids and radar equipment supporting Air Traffic Control operations. This demonstration is the Lean Logistics prototype to be used to evaluate the full logistics pipeline for non-aircraft systems. In the demonstration, base-level repair activities have two days to repair failed items. If an item cannot be repaired, the base repair shop requisitions a replacement from the Sacramento Air Logistics Center and ships the failed item to the depot for repair as soon as possible. All parts less than 150 pounds and not requiring special packaging are shipped by express transportation with a two-day guaranteed delivery. We anticipate this demonstration will validate that smaller inventories, coupled with rapid repair and transportation, will greatly improve logistics support for systems vital to the Air Force mission. (TSgt Dennis Polansky, AF/LGMM, DSN 227-5642)

Recipient Pays Initiative

This HQ USAF/LGT/LGS initiative will result in lateral support transportation costs being paid by the base requesting the lateral support. Currently, the base shipping the lateral support materiel pays the commercial charges for transportation. Each "FB" account supported by the Standard Base Supply System (SBSS) will receive a specific Transportation Account Code (TAC): "F" followed by the base routing identifier code. SBSS will print the TAC onto each DD Form 1348-1A, Issue Release/Receipt Document (shipping document). The recipient base will receive and pay the carrier invoice. AFR 172-1, *USAF Budget Policies and Procedures* (to be replaced by AFI 65-601) identifies payment responsibility. This change is expected to be partially implemented by 1 October 1995 with full implementation following systems modifications. (Thomas Spade, AF/LGTT, DSN 227-4742)

Sustainment Execution Management Report

To better articulate and project the ability to sustain the readiness of major systems, HQ USAF/LG initiated the Sustainment Executive Management Report (SEMR). SEMR uses funding data and a number of key maintenance and supply indicators at wings and depots as the basis for the assessment. The weapon system single manager makes the assessment in coordination with the using commands. Assessments are based on supporting operational requirements for two Major Regional Conflicts (MRC) and are made for the current fiscal quarter, same quarter next year and two years out, and to the end of the Five-Year Defense Plan (FYDP). Assessments are color coded: Green, Yellow, or Red. Any system coded less than Green requires an explanation of what is required to make that system Green. The two SEMRs submitted to date have been exceptionally useful to Air Force leaders in focusing on key sustainment issues for our future. (Lt Col Lisa Gay, AF/LGMY, DSN 227-0311)

Product Improvement

Air Force Instruction (AFI) 21-118, *Improving Aerospace Equipment Reliability & Maintainability (R&M)*, makes some significant changes to the process of identifying R&M problem items. This AFI, which is a replacement for AFR 66-30, *Product Improvement Program*, establishes the Product Improvement Working Group (PIWG) as the primary forum for initiating product improvements. The AFI identifies the Single Manager and the Lead Command as co-chair for the PIWG and increases the importance of user-defined problems as the basis for initiating product improvement. Also, the concept of Lead Wings for aircraft is put forward along with a clear depiction of the operational commands' responsibility for funding R&M improvement. (Lt Col James Pauly, AF/LGMM, DSN 227-3523)

Waiver Procedures for Class I Ozone Depleting Substances

Major changes in waver approval for Ozone Depleting Substances (ODS) are in process. The objective of the new policy is that all organizations that require the use and/or purchase of Class I ODS will possess an approved ODS waiver. This policy implements the Montreal Protocol on Substances that Deplete the Ozone Layer; Clean Air Act and Its 1990 Amendments; National Defense Authorization Act for FY 1993; Department of Defense Directive 6050.9, *Chlorofluorocarbons (CFCs) and Halons*; AFPD 32-70, *Environmental Quality*; and Air Force Instruction 32-7080, *Pollution Prevention Program*. Existing waivers that terminate 31 December 1994 will be extended through 31 May 1995 with no increase in quantity. However, effective 1 June 1995, organizations must have an approved waiver for all ODS purchases and uses. (Marge Larson/Joyce Ross, AF/LGMM, DSN 225-0844; Lt Col Sherman Forbes, SAF/AQXM, DSN 225-4167; or Major Keith Smith, AF/CEVV, DSN 227-2550).

Hazardous Material Pharmacy

The Air Force is beginning several major initiatives to better comply with Environmental Protection Agency (EPA) guidance. Major directives that are applicable include: Executive Order (EO) 12856, *Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements*, 3 August 1993; Department of Defense Directive 4210.15, *Hazardous Material Pollution Prevention*, 27 July 1989; and Air Force Instruction 32-7080, *Pollution Prevention Program*, 12 May 1994. Wing/base commanders are responsible for all legal aspects of complying with these directives.

To assist commanders, the Air Force has established the Hazardous Materials Pharmacy (HMP) concept. The implementation of HMP Air Force-wide will assist commanders in performing their legal responsibilities. The fundamental purpose of the HMP is to minimize and track the ordering, storing, distribution, use, and disposal of hazardous material (HAZMAT) through effective use of single-point control. The HMP will streamline and consolidate existing tasks and perform the new tasks directed by EO 12856. The HMP will require the support and cooperation of several units on an installation to include the medical group's Bioenvironmental Engineering Services, wing commander's staff Safety Office, Civil Engineering, and Supply. An organizational change package is in staffing. (Marge Larson or Joyce Ross, AF/LGMM, DSN 225-0844)

Changes in Expense/Investment Threshold

The Defense Appropriation Act of Fiscal Year 1995 has increased the expense/investment threshold for non-centrally managed equipment from $25,000 to $50,000. Beginning in October 1994, locally managed equipment items/systems costing less than $50,000 must be procured with Operations and Maintenance (O&M) funds. Investment funds (3080 appropriation) must be used for equipment items/systems costing $50,000 or more. Currently, for the three active years (FYs 93, 94, and 95) in the investment accounts, there are three different expense/investment thresholds. For FY93 funds expiring in FY95, the threshold is $15,000; for FY94 funds expiring in FY96, the threshold is $25,000; for FY95 and funds thereafter, the threshold is $50,000. Raising the dollar criteria for the purchase of equipment in the O&M appropriation increases the number/type of equipment items a local commander has the authority to purchase. (Marilyn Gatzke, AF/LGSR, DSN 227-9467)

(Continued from page 27)

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The following article is the first of two articles dealing with Activity Based Costing (ABC). This article serves as a basic introduction to ABC. The second article will focus on how businesses have implemented ABC into logistics.

Activity Based Costing: Accounting Information to Measure, Manage, and Improve Activities and Processes

Captain Robert W. Callahan, USAF
Captain Daniel A. Marion, Jr., USAF
Major Terrance L. Pohlen, USAF, PhD

This article discusses traditional government accounting systems and recent congressional legislation aimed at improving financial management processes within government organizations. As mandates of the congressional legislation are implemented within government agencies, traditional cost systems may not provide managers the information necessary to determine the cost of providing services or the usefulness of expenditures. This article presents an accounting system that may provide insight into organizational costs and performance. This cost system, first developed within private industry, is known as activity based costing (ABC). The information contained in this article has been extracted from a 1994 thesis written at the Air Force Institute of Technology. The thesis, *Applicability of An Activity Based Cost System Within Government Service Organizations*, received the Society of Cost Estimating and Analysis Award for its contributions to the development of and/or application of cost analysis and cost estimating techniques.

Introduction

Traditional government accounting systems were originally designed to provide fund information to managers, not information needed to manage processes and activities. These older, vertically-oriented accounting systems focus on the inputs of the cost management system. The Chief Financial Officers Act of 1990 and the Government Performance and Results Act of 1993 have made it clear that government accounting systems need to be replaced or supplemented with a system that focuses on providing managers with information to measure, manage, and improve activities and processes—a system which focuses on the outputs. ABC was designed to give managers this information and allow them to determine the costs associated with delivering a product or service. This horizontally, process-oriented approach of cost management can be used to develop alternative forms of non-budgetary information and target opportunities within the organization to reduce costs and improve processes. Figure 1 shows how costs can be traced from budget categories to departments, and in turn, to activities and processes within an activity based cost system. Existing government accounting systems meticulously trace costs to budget categories; however, they fail to link budgets with process or product costs. ABC is a methodology designed to give managers this new information.

Background

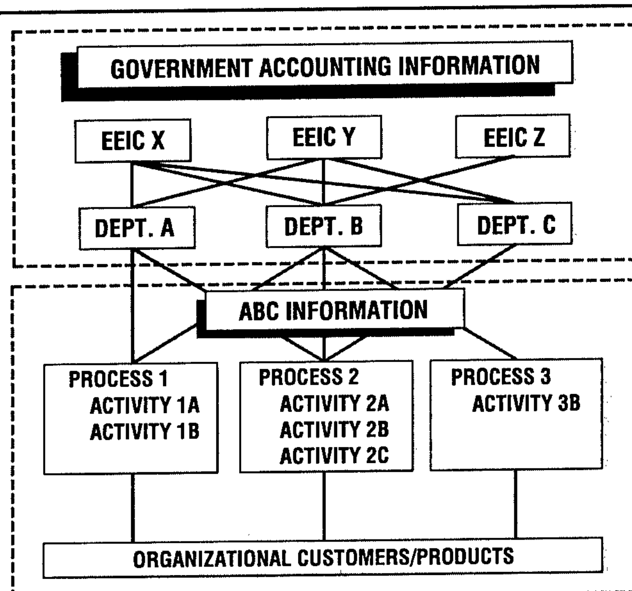
Vice President Gore's book *Creating a Government That Works Better & Costs Less* recognized that the input-oriented nature of government financial accounting systems does not provide a link between budget and operational performance. Government accounting systems do not provide the information needed by managers to measure performance or to manage complex processes and activities. (12:147) Representative John Conyers of Michigan noted that

> our financial management systems are antiquated and too numerous for sound financial management . . . our political culture encourages spending money rather than saving money. (2:24)

Paul Juola, a management analyst with the Department of Defense (DOD) Comptroller, supports Conyers' observation and states that

> for activities financed through direct appropriations, financial managers tend to focus on executing the program rather than minimizing cost . . . the management imperative is to spend the entire budget for fear that budget reviewers (including Congress) would cut the budget. (9:16)

Increasingly, managers within government agencies are becoming aware that shortfalls exist in their financial management systems. For example, the District Commissioner of the Boston Examinations Division of the Internal Revenue Service described his financial accounting system by saying "this is not the way I'd run my own business. I have a responsibility to spend money wisely and I'm not sure that I am now. I am only sure that I am spending it." (6:24)



In this example, Process 3 is performed only by Dept. B, and Dept. C performs only Activity 2C.

Figure 1. Activity Based Costing Cost Model.

Managers within the Defense Logistics Agency (DLA) also found their financial system to be inadequate. In 1987, the Agency's major financial performance goal was simply to ensure expenditures did not exceed obligation authority. In a study of its depot in Mechanicsburg, Pennsylvania, DLA found that "the real incentive was to ensure expenditures were exactly equal to funds provided, because the depot would likely face budget reductions if funds were not expended." (7:16)

In a similar study of a Naval depot, research by Ansari and Euske reported that managers had supplemented the existing financial reporting system with other systems to provide more relevant cost accounting data. In describing the mandated federal accounting system, one manager stated "we don't use it—we comply with it—and for all the trouble it causes us, I sure hope somebody uses it." (6:24)

Government Accounting: A Fund Structure

From its inception, government accounting has evolved into a formal set of complex standards, though the principal means of tracing costs has remained closely linked to the concept of the fund. (15:33) The National Committee on Governmental Accounting (NCGA) defines a fund as

> a fiscal and accounting entity with a self-balancing set of accounts . . . which are segregated for the purpose of carrying on specific activities or attaining certain objectives in accordance with special regulations, restrictions, or limitations. (15:34)

A principal characteristic of this type of accounting is that it allows managers to discern "revenues by source, and expenditures by object." (15:34) Fund accounting is therefore designed to trace costs by specific category; for example, fuel, personnel salaries, and travel reimbursement. This type of financial reporting provides meticulously detailed data regarding the expenditure of funds by category.

Government accounting was designed to trace congressional appropriations to categories of expenditures. As a consequence, the federal financial reporting structure provides managers visibility of expenditures by levels of indenture within the federal government and by specific categories of expenses.

Initiated during the Johnson Administration, Program Budgeting facilitated consideration of policy objectives and resource allocation through groupings of programs. In this manner, congressional budgeters are able to review defense appropriations by major program, organization, and category of expense. The ten major force programs (MFP) in DOD represent the broadest categories of program expenditures. Within each MFP, the accounting system is able to derive the specific costs for organizations. Program Budgeting provides an aggregate depiction of expenditure by federal agency, appropriation category, and fund program. (14)

Within each major force program, there may be several program element codes (PECs). Program element codes identify the organizations that comprise an MFP. For example, MFP 8, which includes training and education, consists of Headquarters Air Education and Training Command and its affiliated organizations. At the organizational level, the budget is usually defined with a single program and thus reflects a single mission. This form of budgeting, known as Object Classification Budgeting, identifies expenditures by category of expense, otherwise known as element of expense investment codes (EEIC). As reflected in Figure 2, the bottom layer of the Object Classification Budgeting structure is composed of EEICs.

This level of detail is managed at the unit level and represents specific categories of expenses within the organization (travel, equipment repair, personal equipment, etc.). The next layer represents the responsibility center/cost center (RC/CC); at this level, organizational financial administrators manage money allocated to each EEIC. As a result of this type of budgeting, costs are traced meticulously within each EEIC and consolidated within each indenture of the budgeting and accounting structure. Object Classification Budgeting, as is the case with Program Budgeting, does not link organization performance to budgets or costs to activities. Instead, costs are traced by element of expense codes and aggregated at each subsequent layer in the accounting process. (14)

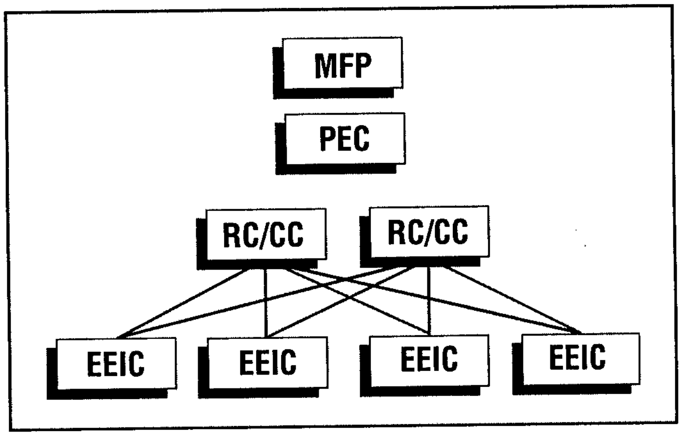


Figure 2. Object Classification Budgeting.

Mandate for Change in the Government Accounting System

In 1990, President Bush signed into law the Chief Financial Officers Act (CFO). This legislation mandated changes in government financial reporting systems and the manner in which tax dollars are managed. (2:24) The essence of this legislation was to address the need for government agencies to develop financial reporting systems that are linked to performance. (5:35) As cited in the CFO Act,

> Financial reporting practices of the federal government do not accurately disclose the current and probable future cost of operating and investment decisions, including the future need for cash or other resources, do not permit adequate comparison of actual cost among executive agencies, and do not provide the timely information required for efficient management of programs. (5:31)

By linking budgets to program outputs and outcomes, the CFO was also designed to help the Executive Branch and Congress finance, manage, and evaluate federal programs. Committed to improving the accounting, financial management, and internal control systems of each agency of the federal government, the CFO Act was also intended to assure the issuance of reliable financial information and to deter fraud, waste, and abuse of government resources. (8:9) As an initial attempt to develop performance-driven budgets and to link costs to services, the CFO Act required the chief financial officer of each government agency to systematically measure and report performance and costs. (17:4)

More recently, the Government Performance and Results Act of 1993 required each agency to "establish performance indicators, measure outputs, service levels and outcomes and compare actual program results to performance goals." (17:5) Together, these two legislative acts seek to expand the information provided by the government accounting system. The present fund accounting system provides input-oriented accounting information about discrete categories of expenditure. An improved accounting system would additionally need to provide output-oriented accounting information to provide a link between budget expenditure and the level and quality of service.

ABC: A Possible Solution

As mandates of the CFO Act of 1990 and the Government Performance and Results Act of 1993 are implemented within government agencies, traditional cost systems may not provide managers the information necessary to determine the cost of providing services or the usefulness of expenditures. Several organizations within the government have adopted an accounting system that may provide improved insight into organizational costs and performance. This cost system, first developed within private industry, is known as activity based costing (ABC).

What is ABC?

In its simplest form, activity based costing is a *technique to accurately assign the direct and indirect costs of an organization to the activities and customers or products which consume the organization's resources.*

In an example of ABC implementation within the DOD, the Air Force Institute of Technology (AFIT) used ABC to allocate overhead to operational departments, and then to determine the cost of the organization's outputs. Figure 3 shows complementary information provided by the government and ABC accounting systems. As you can see, the government accounting system reports categories of expenditures within an organization, the consumption of an organizational budget by operational and overhead departments, and the proportion of the organization's budget that each department or section may consume. However, this information, in its existing form, does not tie expenditures to processes within the organization. Again referring to Figure 3, you see that ABC reports the consumption of overhead by operational departments. Having allocated the indirect costs of the organization to operational departments, ABC was then able to more accurately cost the organization's outputs.

Through ABC implementation, an organization is able to trace its indirect/overhead costs to the activities, processes, and departments that consume them. This methodology provides managers with a more accurate picture of what resources are required to run a department, provide a service, or produce a product.

Why Do You Need ABC?

Recent moves within government toward continuous process improvement and total quality management emphasize the management of business processes and activities. ABC represents one method of tracing organizational resources to activities or processes.

As illustrated in Figure 4, AFIT's ABC model provides a manager information which answers the following questions:

(1) What resources are required to support an activity or process?
(2) What quantity of resources does an activity or process consume?
(3) Which activity or process consumes the majority of the organization's or department's resources?
(4) Who is the customer (or what is the requirement) that causes a process to be performed?
(5) What proportion of each activity performed does a customer consume?

Understanding the resources that activities and processes consume is critical for effective management and decision making. ABC provides this information and can be used to drive process improvement, cost reduction, or reallocation efforts. Activity based costing shifts the cost management focus from managing resource categories to managing the very things that consume resources—activities and processes.

Actual benefits or potential benefits that can be attained by AFIT as a result of their ABC system are listed below and are illustrated in Figures 3 and 4:

(1) As depicted in Figure 3, AFIT's traditional cost accounting system traces costs vertically by function and department, but the building blocks of an organization, those "business processes and activities that transform inputs into outputs," cut horizontally across departments and functions. (10:41) The ABC system, on the other hand, was able to cut horizontally across departments to develop activity and process costs.
(2) As you see in Figure 4, AFIT's ABC system identifies activities and business processes and then traces the cost of resources consumed by an activity to the outputs of that activity. As activities are the building blocks of business processes, identifying and understanding these activities is an essential step in improving business processes. (11:32;4:102)
(3) AFIT's ability to place accurate costs on activities and their outputs provides a clear metric for improvement within the organization, whether for determining improvement priorities in the long-term or for measuring short-term success. (11:35;4:102)
(4) Understanding the relative consumption of resources allows AFIT to assess the contribution each activity makes to overall operations, which is important in controlling and reducing costs. (18:40) It is also possible to determine whether the relative cost of an activity is commensurate with the importance of the activity to its customers and management. Management can use this knowledge to prioritize activities for improvements or cost reductions.

Framework for Implementation

Developing a cost model to explicitly capture the sum of the resources consumed by an activity or process represents a departure from traditional government financial reporting systems that trace costs downward by category. (16:1) This section outlines a general process which can be followed in developing an activity based cost model that will trace expenditures across EEICs to the activities, processes, and products of a government organization. Figure 5 outlines the broad steps this methodology will cover.

Step 1. Management Input

The point of developing an ABC model is to give managers alternative budgetary information that will be useful in making future resource allocation decisions and to depict, with the necessary degree of accuracy, the current allocation of resources across activities and processes. As such, key issues which should be addressed by management prior to implementing ABC are:

(1) What is the purpose of the ABC model?
(2) What level of detail is required in the model?
(3) What organizational costs will the model consider?
(4) How will the model be constructed and maintained?

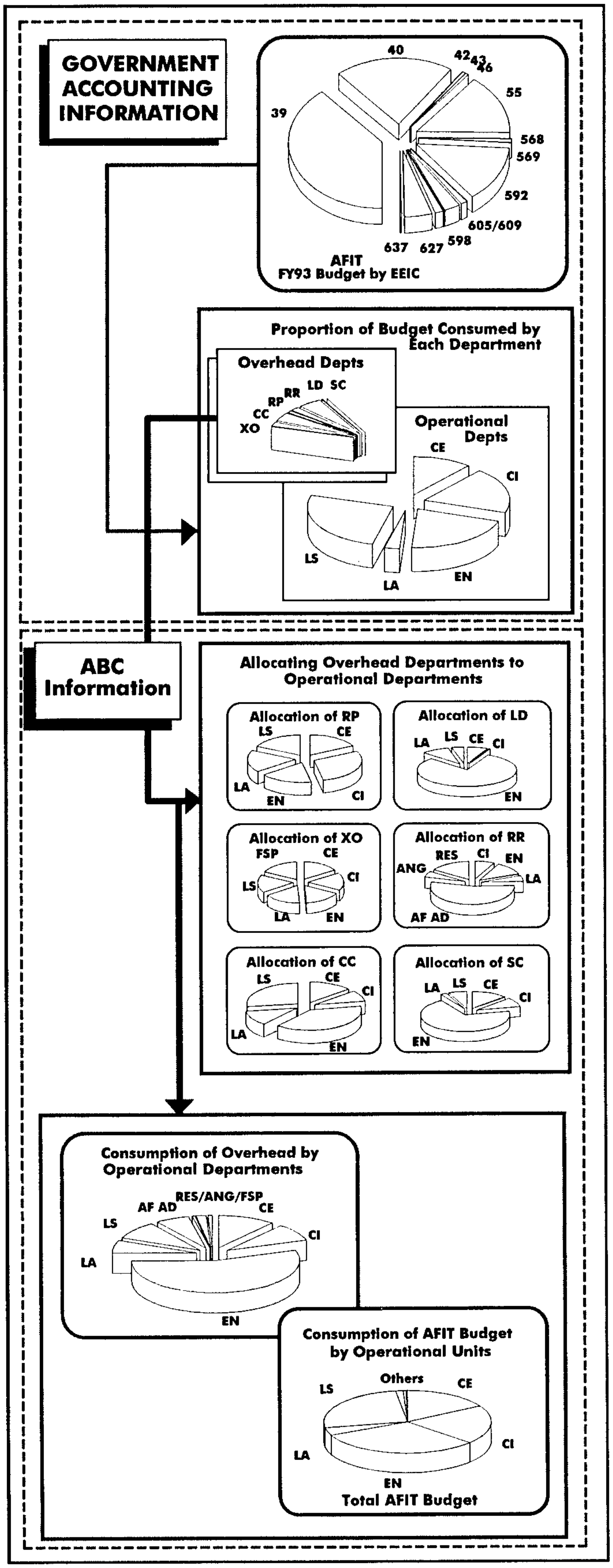


Figure 3. Government Accounting Information Versus Activity Based Costing.

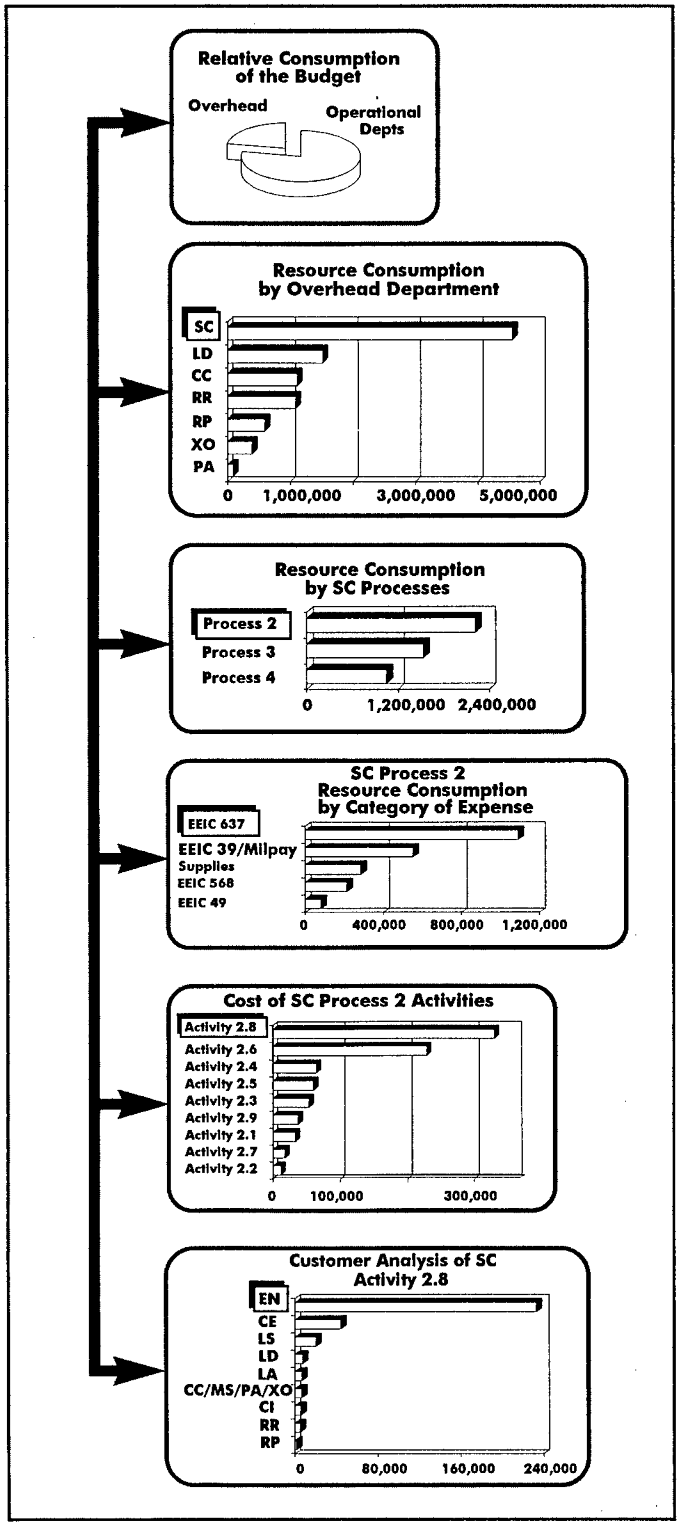


Figure 4. Information to Manage Activities and Processes.

However, "before implementation can take place, significant resources must be devoted to defining activities and establishing methods, procedures and systems to meet the fundamental design objective." (10:46).

Step 2. Create an Organizational Chart of Activities

In developing an ABC system, activities represent the building blocks of business processes. (11:32;4:102) As depicted in Figure 6, preparing an organizational chart of

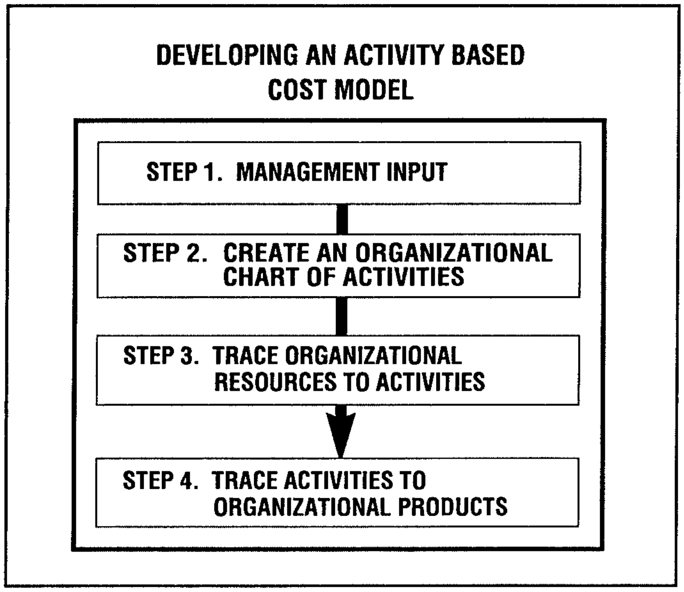


Figure 5. Framework for Implementing ABC.

activities requires the delineation of major processes within organizational departments or sections. Processes are generally thought of as being comprised of activities, and often span across the organization. Following the iterative process depicted in Figure 6, it is best to try and develop a macro view of what a department or section does, and then proceed to detail the activities which comprise each process.

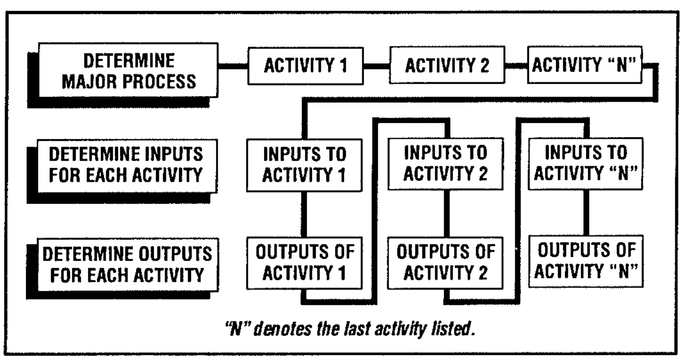


Figure 6. Developing an Organizational Chart of Activities.

Having listed the activities which comprise each process within a department or section, the next step is to trace the consumption of organizational resources by activities and the consumption of activities by products.

Step 3. & Step 4. Trace Organizational Resources to Activities and then to Organizational Products

As shown in the top portion of Figure 3, the government accounting system tracks organizational resource consumption through the use of expense categories. These expense categories trace the cost of operation downward from the aggregate organizational budget to individual departments. However, those business processes and activities that are the organization's mission cut horizontally across departments, and consequently, the government accounting system is unable to accurately determine the cost of providing a service or producing a product.

As seen in the AFIT illustration, ABC provided the information needed to:

(1) Allocate overhead costs to operational departments.
(2) Trace the consumption of resources by activities and processes.
(3) Determine the costs of organizational services and products.

The costs of the activities and processes within overhead departments were primarily based upon the relative consumption of labor hours. A cost was assigned based upon the proportion of labor hours consumed multiplied by the salaries of the individuals performing the activity or process.

The costs of these overhead activities and processes were next traced to operational departments according to the relative consumption of overhead resources. In some instances, a volume-related base; for example, number of personnel serviced by an overhead activity, was used to trace overhead costs to operational departments. In other cases, though, the drivers of the costs of overhead functions were unrelated to volume-related measures like customers served, forms completed, or transactions processed. ABC allowed for the use of multiple cost drivers to trace resource consumption from overhead activities to operational departments.

The bottom portion of Figure 3 shows the relative costs of each operational department. This total cost includes the direct costs, as detailed by the department's budget, plus the cost of overhead resource consumed.

This total cost of an operational department was next assigned to its activities and processes based upon the relative consumption of cost drivers within each department. For example, cost drivers within an AFIT operational department might include the number of degrees awarded, short courses taught, or consultations completed.

Robin Cooper, a noted author in ABC literature, suggests the following criteria should be considered when determining the possible use of *multiple cost drivers* to allocate the consumption of activities:

> *Desired accuracy of reported costs.* The higher the accuracy desired, the more cost drivers required.
>
> *Degree of product diversity.* The greater the degree of product diversity, the more cost drivers required.
>
> *Relative cost of different activities.* The greater the number of activities that represent a significant proportion of the total cost of the products, the more cost drivers required.
>
> *Degree of volume diversity.* The greater the range of batch sizes, the more cost drivers required.
>
> *Use of imperfectly correlated cost drivers.* The lower the correlation of the cost driver to actual consumption of the activity, the more cost drivers required. (3:45)

The selection of a *particular cost driver* will be influenced by the cost and ease of measuring the cost driver and the correlation of the selected cost drivers to the actual consumption by the activity. ABC achieves increased accuracy when compared with traditional cost accounting because of the use of multiple cost drivers.

Cooper writes that the key to keeping the cost of data collection down is to "use cost drivers whose quantities are relatively easy to obtain. This is accomplished in part by substituting drivers that capture indirectly the consumption of activities by product." (3:43) As an example, he suggests that managers measure the number of transactions rather than the duration of individual transactions.

Cooper notes, however, that indirect measurement of cost drivers will be accurate to the degree that the individual transactions are homogeneous and also "reflect the actual consumption of activities." (3:43)

Conclusion

ABC offers several distinct advantages when compared to traditional accounting systems. First, the ABC allocation process provides a foundation for accurately allocating indirect or overhead costs. In turn, a more accurate total cost to operate a department or section is provided. Where traditional accounting traces only direct expenditures to a department or section, the ABC allocation process recognizes the resources consumed from other departments when computing the total resources consumed by a department or section. Consequently, this more accurate total cost may provide managers with more accurate product or service costs. In an environment where services and products are competed, accurate product costing is critical to the livelihood of the organization.

The last implication of this type of cost visibility is that it allows managers to gauge the relative impact of reducing or eliminating an overhead department, process, or activity. Where the traditional accounting system traces only direct expenditures to departments, and subsequently to processes or activities, the ABC allocation process spans the entire organization and provides managers with the total resources that support an activity, process, or department. In short, this allocation process answers the question, "If this service or department is reduced or eliminated, what resources would I expect to go with it?"

Applications of ABC have mainly been implemented in manufacturing organizations, but increasingly the benefits of ABC have been realized in service organizations as well. ABC also appears well suited for expansion into government organizations. "Though research about activity based costing was originally directed toward the manufacturing sector of our economy, the wider concept of Activity Based Management applies equally well to service, not-for-profit, and governmental organizations." (1:13)

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New Computer System Tracks Logistics Traffic for DOD Units

The Defense Automatic Addressing System Center at Gentile Station has flipped the switch on a new computer system that will enable military activities worldwide to inquire about the status of material they have ordered and obtain on-the-spot information on other transactions.

Costing about $15 million, the Logistics Information Processing System (LIPS), as it is known, is designed to process and archive vital logistics data and make it readily available to users throughout the world. It can process 5 million transactions a day and will provide service to 175,000 subscribers worldwide.

The system is designed to serve all levels of logistics activity within the Department of Defense (DOD) which supports the warfighter. Subscribers include units of the Army, Marine Corps, Navy, Air Force, Coast Guard, Defense Logistics Agency, General Services Administration, and other federal agencies. The system will also be used by foreign military customers who requisition materials through the US military supply system.

As such, field units can interrogate the system database for information about the status of their requisitions, available surplus material, and other purposes. LIPS gives users complete visibility over all assets in the DOD inventory. For instance, an Army unit ready to deploy on a mission can inquire about the expected shipment dates of all parts its has ordered, giving it a planning tool not previously available.

The system is described as a 21st century solution to the problem of gaining complete visibility on assets. While the data used to track activity has been available for many years, it required sequentially scanning large numbers of files. Getting an answer to a question could require up to three weeks of research. Such information is now instantly available. LIPS, in fact, can access 90 days of logistics data in seconds from robot-operated data files. Older data is also available through an advanced archiving system supported by optical disk. Raw data such as document numbers, addresses, and status codes can be retrieved in context and arrayed in an easily interpreted, accessible manner. The ultimate intent of LIPS is to maximize information to combat forces.

The system will be especially helpful as a management device to perform studies that will improve maintenance of the DOD inventory and the flow of supplies from contractors to depots to customers.

The system was developed for the Defense Automatic Addressing System Center by AmerInd, Inc., a Native American company based in Alexandria, Virginia.

The Defense Automated Addressing Systems Center opened in 1965 to accurately route and distribute logistics transactions throughout DOD. It opened a second site in California the following year. In 1982, the organization began a major effort to modernize its computer hardware and software assets. Over the 12-year period, it has acquired hardware and software from six major computer companies and reengineered application programs on the new computers while serving its customers 24 hours a day.

The new systems were integrated by the center's staff, using assistance from local contractors. The Logistics Information Processing System represents the culmination of the modernization effort to facilitate the flow of logistics data and to provide detailed information to subscribers along the worldwide network.

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